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Proceedings of the Pacific Slope Branch of the American Association of Economic Entomologists

The third annual meeting of the Pacific Slope Branch of the American Association of Economic Entomologists was held at the Citrus Experiment Station, Riverside, California, on March 28th, and on the following day at the Branch Laboratory of the State Insectary at Alhambra. In the afternoon of March 28th, a field excursion was made to the Yucaipa apple section about twenty-five miles from Riverside, and on the afternoon of the 29th an inspection was enjoyed of the famous Huntington gardens at Pasadena through the courtesy of the Superintendent, Mr. Hertrick. The government entomological laboratories at Alhambra, representing the divisions of citrus and subtropical fruits, and truck crops, were also visited.

PART I. BUSINESS PROCEEDINGS

The first meeting, which was held in the lecture room of the Citrus Experiment Station, was called to order by President G. P. Weldon at 10 a. m. Thursday, March 28th. The following members and visitors were present:

E. F. Atwater, U. S. Dept. Agr., Washington, D. C.
F. A. Bahmeier, Farm Adviser, San Bernardino, Cal.
J. T. Barrett, Citrus Experiment Station, Riverside, Cal.
J. C. Bradley, Cornell University, Ithaca, N. Y.

E. J. Brannigan, State Insectary, Alhambra, Cal.
O. B. Burger, Citrus Experiment Station, Riverside, Cal.
R. E. Campbell, U. S. Dept. Agr., Alhambra, Cal.
G. A. Coleman, University of California, Berkeley, Cal.
G. S. Demuth, U. S. Dept. Agr., Washington, D. C.
R. W. Doane, Stanford University, Cal.
H. T. Fernald, Massachusetts Agricultural College, Amherst, Mass.
S. B. Freeborn, University of California, Berkeley, Cal.
G. P. Gray, University of California, Berkeley, Cal.
A. S. Hoyt, Quarantine Office, Los Angeles, Cal.
D. B. Mackie, State Commission of Horticulture, Sacramento, Cal.
C. B. Messenger, California Cultivator, Los Angeles, Cal.
E. L. Morris, County Horticultural Commissioner, Santa Ana, Cal.
J. D. Neuls, Braun Corporation, Los Angeles, Cal.
C. A. Parrin, State Insectary, Alhambra, Cal.
H. J. Quayle, Citrus Experiment Station, Riverside, Cal.
H. J. Ryan, U. S. Dept. Agr., Alhambra, Cal.
H. P. Severin, University of California, Berkeley, Cal.
D. D. Sharp, County Horticultural Commissioner, Riverside, Cal.
H. S. Smith, State Insectary, Sacramento, Cal.
A. F. Swain, Citrus Experiment Station, Riverside, Cal.
R. S. Vaile, Citrus Experiment Station, Riverside, Cal.
G. P. Weldon, State Commission of Horticulture, Sacramento, Cal.
R. S. Woglum, U. S. Dept. Agr., Alhambra, Cal.
H. D. Young, U. S. Dept. Agr., Alhambra, Cal.

President G. P. Weldon: The meeting will please come to order. In the absence of the Secretary, E. O. Essig, it will be necessary to have some one act in that capacity.

H. J. Quayle was nominated to act as Secretary for the meetings. The report of the Secretary and Treasurer was not presented.

The following applications for associate membership were recommended to the regular membership committee of the Association for final action:

Bridwell, J. C., Honolulu, H. T.
Clausen, C. P., State Insectary, Alhambra, Cal.
Kimsey, M. E., Scottsvale, Ariz.
Mackie, D. B., State Insectary, Sacramento, Cal.
Penny, D. D., State Insectary, Sacramento, Cal.
Vosler, E. J., State Insectary, Sacramento, Cal.
Ryan, H. J., Alhambra, Cal.

The second part of the business meeting was held at Alhambra, on Friday, March 29th, at which meeting President G. P. Weldon also presided.

President G. P. Weldon: At our last meeting a committee on entomological research was appointed and I will now call upon Professor Doane, the chairman of that committee for the report.

REPORT OF THE COMMITTEE ON ENTOMOLOGICAL RESEARCH

By R. W. Doane, *Chairman*

This committee was appointed to coöperate with the Pacific Coast Research Conference of the State Council of Defense. The committee outlined a series of problems which it thought it would be advisable to undertake, but the Executive Committee, owing to lack of funds, were not able to authorize this work.

In spite of this, two of the projects proposed were undertaken. The first was a continuation of the study of the mosquito situation in California, the State Board of Health coöperating in this and furnishing funds. The second was an investigation of the insects affecting stored foods in warehouses and mills. This work was done with the coöperation of the Federal Food Commission of California, which furnished funds for the purpose.

President G. P. Weldon: We will now proceed to the election of officers.

A motion was made and carried that the nominating committee be dispensed with and that nominations for officers for the ensuing year be made from the floor. The following officers were elected:

President—H. J. Quayle.
Secretary-Treasurer—E. O. Essig.

The following were appointed to the committee on membership: R. S. Woglum, H. S. Smith and R. W. Doane.

The meeting adjourned with the tentative understanding that the next annual meeting would be held in connection with the Pacific Coast Branch of the American Association for the Advancement of Science.

H. J. Quayle,
Acting Secretary.

PART II. PAPERS AND DISCUSSIONS

In the absence of a formal paper, President G. P. Weldon made a few appropriate remarks, calling particular attention to the practical things that entomologists may do at this time in the conservation of foods and food products.

President G. P. Weldon: I will now call for the reading of papers and the first one is by O. F. Burger and A. F. Swain, entitled "A Fungus Enemy of the Walnut Aphis."

OBSERVATIONS ON A FUNGUS ENEMY OF THE WALNUT APHIS IN SOUTHERN CALIFORNIA[1]

By O. F. Burger, *Instructor in Plant Pathology*
and
A. F. Swain, *Assistant in Entomology*

Introduction

In the spring and early summer of 1917 the walnut aphis (*Chromaphis juglandicola* Kalt.) was very abundant in the various walnut growing sections of Southern California. In many places the infestations were so severe that control measures were inaugurated. This was especially true in the vicinities of Santa Barbara, Santa Paula, El Monte and Tustin. Several growers dusted their trees with combinations of dry sulfur and tobacco dust, in an attempt to control both the aphids and the walnut blight. Under the direction of the Department of Entomology of the Citrus Experiment Station, portions of the walnut groves of the San Joaquin Fruit Company, near Irvine, Orange County, were sprayed in the latter part of May, with nicotine sulfate and lime sulfur, and with nicotine sulfate and soap, with excellent results in controlling the aphids. A grove near Santa Paula was sprayed about the same time with nicotine sulfate and soap under the direction of the Ventura County Horticultural Commissioner, with equally good results.

As stated above the infestation of walnut aphis was exceedingly heavy, and gave promise of causing considerable loss. Even in Riverside County where ordinarily this aphis is of no importance whatever, a severe infestation occurred during the latter part of May and in June. One hundred leaves from a tree in Riverside on June 8, showed an average of about 70 aphids per leaf, which is an extremely large infestation for that vicinity. On June 6, in a grove in Santa Ana, an average of 106 aphids per leaf was counted, while the grower informed the writers that two weeks earlier there had been many more present. In the Thorpe grove near Santa Paula on June 11, there was found to be an average of 62.5 aphids per leaf, and on the Limoneira Rancho a few days later, about 22 per leaf were noted. The great abundance of aphids was also observed in Santa Barbara County at Carpenteria, Naples and Santa Barbara; in Los Angeles County at El Monte, Spadra and Walnut; and in Orange County at Anaheim, Orange and Tustin.

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[1] Paper No. 49, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

Field Investigations

Several groves in the vicinity of El Monte were heavily infested and many of them were treated. The observations were confined to the groves of the Cogswell Ranch which were dusted with various combinations of sulfur and tobacco dust during the latter part of May. A few days later the owner noticed that the infestation was considerably lighter. On June 4, the writers examined these groves and found that the aphids to a large extent had disappeared. Bodies of many dead aphids were observed still clinging to the leaves, and these were thought at first to have been killed by the dust, but they were also observed on untreated trees. It was further noticed that live aphids were no more numerous on the untreated than on treated trees. A microscopical examination of the bodies of the dead aphids brought out the fact that they were infected with a fungus which later proved to be a new species of *Entomophthora*.

The discovery of aphids infected with this fungus resulted in a more thorough examination of the conditions on June 9. Table 1 gives the results of counts made on the various groves.

Table 1—Walnut Aphis in Cogswell Groves, El Monte, July 9, 1917

	Number of leaves	Number of aphids per leaf	Percentage of aphids infected	Number of living aphids per leaf
A Treated	30	40.07±2.87	87.02±1.51	5.93±0.65
B Treated	50	17.56±0.94	73.12±2.27	4.72±0.64
C Treated	50	28.94±1.50	71.73±1.73	8.18±0.69
D Untreated	49	42.18±2.80	88.56±1.17	5.16±0.39
E Untreated	40	38.60±2.67	83.81±1.33	6.17±0.94

An examination of this table shows that the average number of aphids per leaf ranged from 17 to 42 in the various groves, but on account of this fungus the average of living aphids was only 5 to 8 per leaf, the percentage of infection being about the same in all groves, both treated and untreated. It must be borne in mind that the number of aphids per leaf does not represent a true record of the previous infestation, for many of the dead aphids had either fallen to the ground or been blown off the leaves. However, this table does show that the fungus was a very important factor in the elimination of the aphids.

Observations were made in Ventura County about this time, where it was found that aphids were present in great numbers but that the fungus was also present. On May 11 one grove near Santa Paula was found to be heavily infested. It was also observed that a small percentage of infected aphids were present. On June 11 not a single

living aphid could be found in this grove, although the mummified bodies of dead aphids were abundant. Unfortunately no counts were made at either examination. It is not claimed by the writers that the fungus was the sole agent in the eradication of the aphids on this grove, for large numbers of ladybird beetles and larvæ, and of syrphid fly larvæ were observed at the time of the first examination. However, the fact that such a large number of infected bodies was present, when living aphids were absent, proves that the fungus was an important agency in controlling the aphis.

Natural Factors in the Control of the Walnut Aphis

During the week June 11 to June 18, extremely high temperature and correspondingly low humidity prevailed throughout Southern California. In fact, that week was the hottest period for the time of year ever reported in Southern California. Table 2 gives the maximum temperatures recorded at various points for the week.

Table 2—Maximum Temperatures (F.°), Week Ending June 19, 1917[1]

June	12	13	14	15	17	18
Los Angeles	79	80	100	99	105	85
Santa Ana	79	87	104	95	97	83
Pomona	93	99	110	112	117	100
Riverside	98	105	112	114	117	103
Santa Barbara	76	80	92	105	115	77

This extreme heat resulted in the death of a large percentage of aphids throughout the walnut growing sections of Southern California, and was by far the most efficient check of the season. In only one case were any living aphids observed by the writers during the following week. This was on the Limoneira Rancho, Santa Paula, where on June 19 there was an occasional aphid found. Such aphids were found only on leaves well in the interior of large trees, where they were protected considerably from the heat.

Among the natural agents which contribute to the control of this aphid, the heat of summer can be mentioned as very important in certain sections. To this heat is largely due the credit for the practical absence of the walnut aphis in such interior sections as Riverside, Elsinore and Hemet. In harmony with this is the fact that in cool, humid weather the aphids seem to thrive best. The early part of the season of 1917 was cool and humid, and this condition lasted until June.

[1] These records were obtained from the Daily Weather Map, United States Department of Agriculture, Weather Bureau, Los Angeles, California, June 13-19, 1917, with the exception of those for Santa Ana which were obtained from the records of a thermograph placed in the Rohrer Grove, by the Department of Plant Pathology of the Citrus Experiment Station.

Insect Enemies

Insect enemies of the walnut aphis, particularly the predaceous enemies, are a very important factor in their control. Observations by the writers showed that these were present everywhere, in some cases being very abundant and apparently accomplishing a great reduction in the aphid infestations. Among the more common enemies may be mentioned the ashy gray ladybird beetle (*Olla abdominalis* Say). About the middle of May the eggs of this species were abundant in the vicinity of Santa Paula, El Monte, Walnut and Tustin. By the latter part of the month, the larvæ were present and feeding extensively on the aphids. These pupated in early June and the adults appeared shortly before the extreme heat. On the San Joaquin Fruit Company's groves, these were very abundant.

Another common predaceous enemy was *Hippodamia convergens* Guerin, the larvæ and adults of which were present from May to September in all groves examined by the writers. The third in abundance was the green lace wing (*Chrysopa californica* Coquillet), which was very plentiful in May and June in Ventura, Los Angeles and Orange Counties. From time to time larvæ of various syrphid flies, particularly *Catabomba pyrastri* (Linnæus), were noted, although never in any great numbers. Occasionally larvæ of *Sympherobius angustus* (Banks) were found, and in the vicinity of Walnut and Spadra, Los Angeles County, adults and larvæ of *Scymnus* sp. were observed. The inclination is to give predaceous enemies credit for any reduction of aphids not proven to be directly attributed to other agencies, as for instance the heat and fungus parasites.

Reinfestation of Groves

About six weeks after the hot weather mentioned above, an examination of the walnut groves of the San Joaquin Fruit Company was made. The aphids were still very scarce. A count of 186 leaves gave an average of 6.54 ± 0.30 aphids per leaf, showing that as yet they had not been able to reëstablish themselves to any great extent. By September 12, three months after the excessive heat, a count was again made, 50 leaves showing an average of but 12.02 ± 1.39 aphids per leaf. In that vicinity, however, the summer had been dry and warm, which together with the predaceous enemies had kept the infestation down. Table 3 gives the results of a count made on the Cogswell groves, El Monte, on September 12.

TABLE 3—WALNUT APHIS IN COGSWELL GROVES, EL MONTE, SEPTEMBER 12, 1917

	Number of leaves	Number of aphids per leaf	Percentage of aphids infected	Number of living aphids per leaf
B	30	84.57± 5.14	1.42±0.27	83.33± 5.14
D	10	63.10±12.71	1.43±0.96	62.20±12.81
F	20	51.30± 6.11	3.51±1.46	49.50± 6.17

An examination of this table shows that practically three months after the hot period, the aphids had been able to reinfest these groves quite extensively. At that time, however, the fungus, although present, was a negligible factor in control, since less than 2 per cent of the aphids were infected. The practical absence of the fungus was due undoubtedly to the summer heat and drought. However, at that season of the year, aphid infestations are of no commercial importance.

OBSERVATIONS AT SANTA ANA

In Santa Ana, Orange County, the Department of Plant Pathology of the Citrus Experiment Station had two walnut trees enclosed in a frame covered with cheesecloth for the purpose of studying walnut blight. Temperature and evaporation records were kept throughout the summer both within one of these frames and outside in the grove. It may be noted that the temperatures from August 1 to September 20 (the period of observations on the aphids) were practically the same outside as inside the frame, being but one or two degrees lower on the average inside. However, the humidity as obtained by the amount of evaporation recorded by the Livingston atmometers was higher within the tent than without. In fact, there was marked difference (see chart I).

It was noted (see Table 2) that in this locality the maximum summer temperature was 104 degrees F, which was considerably lower than in most of the sections of Southern California where any observations were made. Also the humidity there is comparatively high. As a result the infestation was not so depleted in June as in other localities. On July 26 under tent 1, a count of the aphids on 35 leaves showed an average of 44.51±4.09 aphids per leaf, with a mortality of 94.43±0.25 per cent caused by the fungus. On August 1 no live aphids could be found on this tree.

About every two weeks, from August 1 until September 20, counts were made of the number of aphids on leaves from the tree under tent 2, and on trees in the surrounding grove. The results of the counts are included in Tables 4 and 5.

CHART I
RELATIVE EVAPORATION

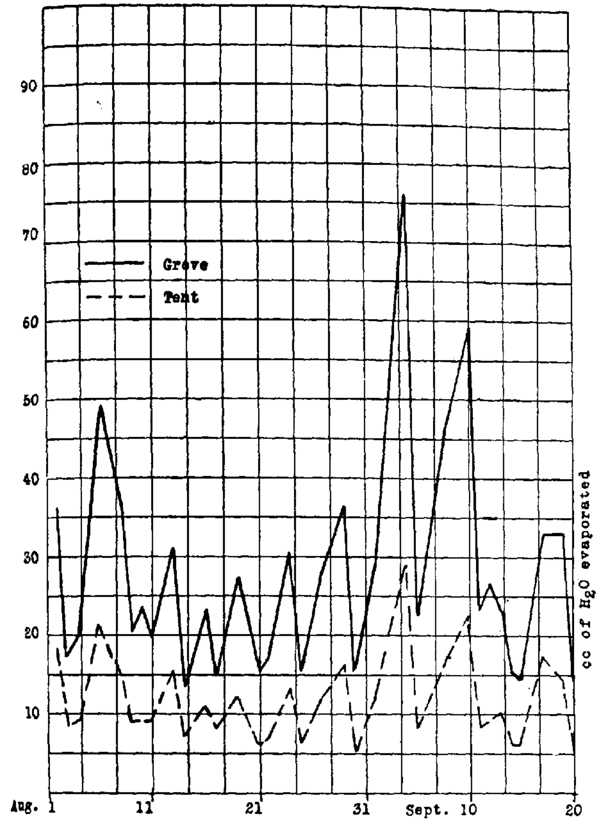


TABLE 4—WALNUT APHIS IN GROVE IN SANTA ANA, ORANGE COUNTY

Date	Number of leaves examined	Number of aphids per leaf	Percentage of aphids infected	Number of living aphids per leaf
August 1........	60	41.35± 3.17	0.48±0.29	41.10± 3.17
August 16.......	10	131.70±16.86	4.56±1.07	125.90±16.86
August 30.......	20	35.25± 3.74	37.45±2.24	34.55± 2.68
September 12....	20	13.60± 2.21	93.38±1.60	0.90± 0.20
September 20....	10	8.80± 0.81	94.45±1.24	0.20± 0

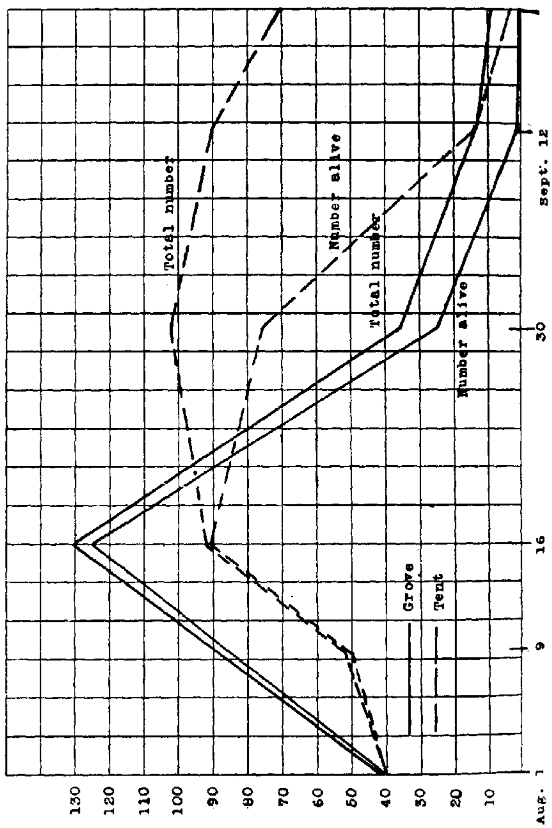
TABLE 5—WALNUT APHIS IN TENT 2, SANTA ANA, ORANGE COUNTY

Date	Number of leaves examined	Number of aphids per leaf	Percentage of aphids infected	Number of living aphids per leaf
August 1........	20	40.00±11.28	0.	40.00±11.28
August 9........	13	50.23± 9.55	0.15± 0.36	50.15± 9.56
August 16.......	10	91.80±10.50	1.20± 0.30	90.70±10.33
August 30.......	10	102.30± 4.45	25.71± 2.95	76.00± 4.50
September 12....	10	89.80± 9.95	84.97± 1.99	13.50± 2.19
September 20....	10	70.50± 7.91	95.60± 1.16	3.10± 0.98

On August 1 it was found that the grove there was an average of slightly over 41 aphids per leaf, of which about one half of 1 per cent

CHART II

AVERAGE NUMBER OF APHIDS PER LEAF



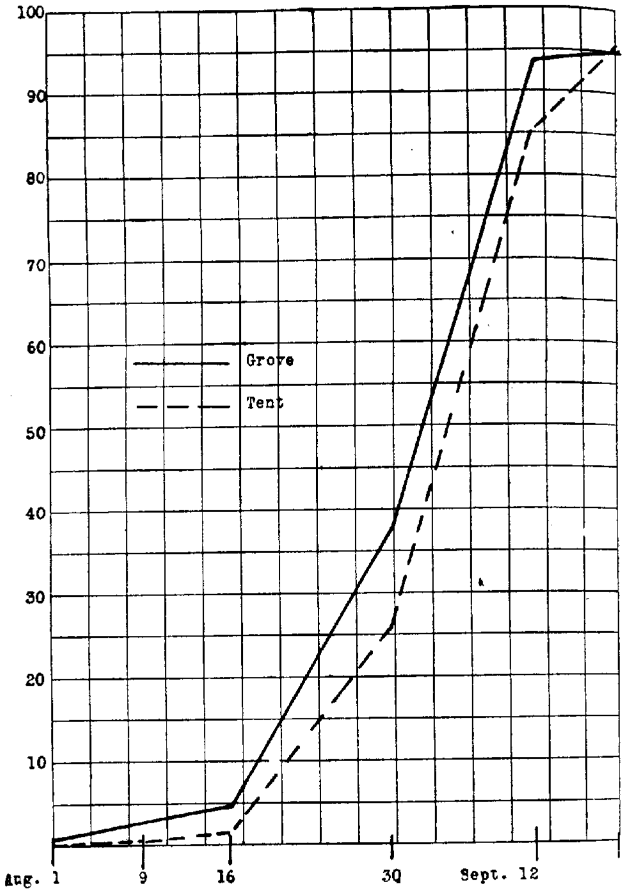
were infected with the fungus. In the following two weeks these increased greatly, until on August 16 there were present about 132 aphids per leaf. The percentage of infection had also increased, but not so rapidly, there being about 4½ per cent of the aphids killed by the fungus. In the next two weeks the number of aphids per leaf had dropped to but slightly over 35, of which some 37 per cent were infected. Two weeks later, on September 12, only about 13 aphids per leaf remained, and over 93 per cent of these were infected with the fungus, leaving an average of a little less than one aphid per leaf alive. By September 20 the number had increased to almost 9 per leaf, but again the percentage of infection was high, being almost 95 per cent, with the result that the aphids were practically eradicated.

This almost complete eradication is accounted for by the action of the fungus together with other natural agencies. Which of these was the most important the writers cannot state, but the presence of the mummified bodies of aphids infected by the fungus permits the interpretation that this parasite was largely responsible for this great mortality.

More convincing results are obtained from a study of Table 5. This is a record of counts made on the tree under tent 2, from August 1 to September 20. During observations covering a period of four months (June to September) no insect enemies of the walnut aphis were ever found in this tent. No specimens of *Coccinellidæ, Syrphidæ* or *Chrysopidæ* were seen, yet results parallel to those observed in the grove were found. On August 1 an average of 40 aphids per leaf was present and none were infected by the fungus. This tree had been sprayed in the spring before the buds opened with lime sulfur, with the result that no aphids appeared until very late. In fact it was at this time that the first real infestation was noticed. These probably were the succeeding generations of some few that gained entrance accidentally from time to time during the summer. By August 9 they had increased, as might be expected, to about 50 per leaf, with a small percentage infected with the fungus. A week later the number per leaf was found to be about 92, with about one dead as a result of fungus attack. Approximately 102 aphids per leaf were present on August 30, but by this time the percentage of infection had increased to 25.71 per cent, with the result that only 76 per leaf remained alive. These increased to about 90 aphids per leaf in the next two weeks, the number infected increasing as well, although in greater proportion. Almost 85 per cent were so infected, leaving but 13.5 per leaf alive. On September 20, when the last observation was made, there were found to be 70.5 aphids per leaf on an average, of which 95.6 per cent were infected by the fungus, leaving only slightly more than 3 aphids per leaf alive.

CHART III

PERCENTAGE OF INFECTION



Here the infestation had been almost eradicated without the aid of any predaceous insect enemies. Charts II and III show the amount of infestation and percentage of infection in the grove and in tent 2.

Other Hosts

Clinging to the under side of the walnut leaves was often found a small bark louse belonging to the genus *Psocus*. These bark lice

were examined from time to time as they were found, and without any exception they were infected with this same *Entomophthora*.

Description of the Fungus

During the spring of the year and in places where the humidity is rather high due to the fogs, an *Entomophthora* is parasitic upon the walnut aphis, *Chromaphis juglandicola* (Kalt.). The disappearance of this insect during the summer months was always thought to be due to heat and predaceous insects. Only one record has been found where a fungus was responsible for the control of this pest.[1] The writers have been unable to learn whether or not this was the same fungus as that herein described.

This fungus attacks the aphid in all its stages of growth from the mature winged form to the small first instar larva. One of the first signs of parasitism of the insect is the sluggish movement of the individual attacked. Later the body turns a darker yellow and is somewhat swollen. Then from the body of the dead aphid the small hyphæ begin to protrude, which in due time form a white fringe about the body (pl. 9, fig. 1). In some cases the protruding hyphæ are in such numbers that the insect looks like a white, glistening, spherical mass, which later turns a light brown in color. When the bodies of the insects are crushed and placed under the microscope, they are seen to be filled with large septate anastomosing hyphæ. These mummified bodies remain for some time, hanging to the leaves by means of haustoria until removed by some external agency.

The spores of the fungus are bell-shaped with a sharply pointed apex (pl. 9, fig. 2). These spores are borne on a club-shaped conidiophore. When the spore is mature, it is shot from the conidiophore with considerable force. Clinging to the spore is a mass of protoplasm that glues it to any object which it happens to strike. If the object happens to be the body of an insect, the spore germinates and the germ tube penetrates the insect. If, however, the spore happens to strike an unfavorable object for its growth, it again forms a secondary spore (pl. 9, fig. 3), which is much smaller but is ejected in the same manner, and the process is repeated until the spore either is exhausted or finds a suitable host. On the wings and legs of the affected insects could be seen many of the discharged spores imbedded in a cushion of protoplasm. Many of these spores had germinated and produced the secondary spores.

Some of the dead aphids were black and were thought to be attacked

[1] Davidson, W. M. Walnut aphids in California. U. S. Dept. Agr., Bull. 100, page 35, 1914.

by a *Cladosporium*, but when examined under the microscope they were found to be filled with dark brown spherical bodies about 30 microns in diameter. These spherical bodies are believed to be the resting spores of the fungus. An attempt was made to germinate the resting spores but with no success.

Entomophthora chromaphidis n. sp.

Conidia bell-shaped with broad truncate base and sharply pointed apex; 11–14 microns by 10–11 microns; usually containing a single large oil globule, and surrounded after discharge by a mass of protoplasm. Conidiophores simple or compound; broad at the apex and gradually tapering to a narrow base; producing white or brownish masses which may or may not coalesce over the body of the host. Secondary conidia oval with rounded apex and formed by direct budding from the primary spore.

Resting spores, azygospores, brown, 30 microns in diameter. Host attacked by rhizoids.

Host: *Chromaphis juglandicola* (Kalt.), *Psocus* sp.

Habitat: California.

Explanations to Plate 9

Fig. 1. The fungus growing from the body of an aphid making a white fringe.

Fig. 2. A discharge spore embedded in the ejected mass of protoplasm.

Fig. 3. A discharge spore producing the secondary spore.

Summary

1. In the spring of 1917 the walnut groves of Southern California were heavily infested by *Chromaphis juglandicola* (Kalt.).

2. Although a period of extreme heat in June, and the presence of numerous insect enemies throughout the season were responsible for the death of a large percentage of these aphids, it was noted that a fungus also contributed to their mortality.

3. Before the period of extreme heat, in El Monte, as high as 88 per cent were killed by this fungus (*Entomophthora chromaphidis* n. sp.).

4. Some time after this period of extreme heat, the aphids increased rapidly but under the conditions noted were effectively controlled by this fungus.

President G. P. Weldon: This paper is now before you for discussion.

H. S. Smith: Have you tried to infect the aphids artificially with this fungus?

O. F. Burger: No opportunity was presented during the past year.

H. S. Smith: Do fungus enemies control the white-fly in Florida?

O. F. Burger: In certain instances, as at Datonia where more or less close observations were made, fungus enemies did seem to control

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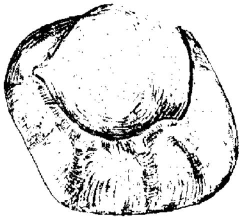

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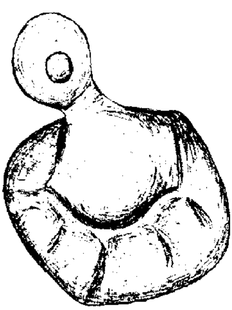

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the white-fly, but they do not effect commercial control in the high pine lands. At Datonia the fungus was sprayed on to the trees, so that it was a case of the artificial use of the fungus.

R. S. WOGLUM: I understand that the lime sulphur which is used in Florida prevented the development of the fungus. In your paper the lime sulphur did not appear to have any effect on the fungus in this State.

O. F. BURGER: As I recall the experiments, lime sulphur did check the fungus, as well as the insects, but where the trees were sprayed with Bordeaux, the fungus was unable to thrive, but the insects multiplied rapidly.

G. P. GRAY: The difference in the effect of sulphur may be different according to the fungus in question, as for instance, the downy mildew and the powdery mildew.

R. S. WOGLUM: How does the Entomophthora fungus enter the insect?

O. F. BURGER: The spores of the fungus are discharged from the conidiophore with considerable force. Adhering to each spore is considerable protoplasm, so whatever object the spore strikes it becomes glued to it. If the spores happen to hit an insect it becomes glued to the body. The spore then germinates and the hyphæ enter the insect.

PRESIDENT G. P. WELDON: The next paper is by William M. Davidson, on "Alternation of Hosts in Economic Aphids," which will be read by A. F. Swain.

ALTERNATION OF HOSTS IN ECONOMIC APHIDS

By W. M. DAVIDSON, *U. S. Bureau of Entomology*

In recent years considerable strides in forwarding our knowledge of the peculiar habit of many of the *Aphididæ* to the alternation of host plants have been made.

This work has centered mainly about plant-lice of economic interest.

True alternation of hosts implies a summer host or hosts and a winter host or hosts, the latter harboring the egg or dormant stage and a series of actively feeding spring generations and the former supporting only actively feeding generations through the summer and fall. Almost invariably the summer and winter hosts are widely separated in a botanical sense. Frequently there is more than one summer host and these are not necessarily close botanical relations. On the other hand the winter hosts are generally few and always, when more than one, closely related. Thus we find the Hop Aphis (*Phorodon humuli*

Schrank) alternating between hop and plum, two plants widely separated botanically, or the Black Cherry Aphis (*Myzus cerasi* Fabr.) migrating back and forward between cherry and *Lepidium*, a small cruciferous plant. Again the summer forms of the Spinach Aphis (*Myzus persicæ* Sulz.) are equally at home on lettuce, a composite, on turnip, a crucifer, or on parsley, an umbellifer. Similarly the Bean Aphis (*Aphis rumicis* L.) feeds in summer upon leguminous and Chenopodiaceous plants alike.

In many of the species complications exist by reason of the fact that the insects may live the year around on the summer host or hosts. The root-inhabiting species all have this habit: the Beet Aphis (*Pemphigus betæ* Doane) normally winters on *Populus* but colonies may occur on beet or other roots any time of the year, and similarly the woolly aphids of apple and pear (*Eriosoma lanigerum* Haus. and *E. pyricola* B. & D.) pass the winter in a dormant state on elms and in an active state on apple and pear, the normal summer hosts respectively. It might here be observed that in California, at least in localities where both the apple and pear woolly aphids abound, the spring forms of the pear insect are very commonly marked on elms whereas these forms of the apple species are quite rare on the winter host.

In the southern and southwestern portions of the United States the semi-tropic climate is mild enough to allow aphids to feed and reproduce through the winter months. Thus several species which in the temperate conditions in the north hibernate only in the egg stage on their winter hosts, in the south pass the whole year on the summer hosts without suspending reproductive activity. Such a form is the Spinach Aphis (*Myzus persicæ*). In the north the winter is passed in the egg stage on stone fruits and the resultant spring generations at times do much damage to these trees, but in the south the aphids feed on vegetable crops and weeds without performing their cycle on the fruit trees, this habit thereby eliminating injury to these tree hosts. Another such species is the Oat Aphis (*Aphis prunifoliæ* Fitch) which winters in the north on apple but in the south reproduces the year around on grasses and grains, and therefore in the semi-tropic zone apples escape injury from *prunifoliæ*. It should be stated, however, that due to their viviparous reproduction throughout winter both these species are liable to occur in spring on the summer hosts in greater abundance in the south than in the north, and thus the absence of injury to the fruit trees is counterbalanced by increased infestation on vegetable and grain crops.

In considering the different aphid species of economic importance, it is found that in a few cases both the winter and summer hosts are economic plants. In this group we find *Myzus persicæ*, an aphid

with a long list of hosts comprising most of our cultivated plants, and *Aphis prunifoliæ*, principally a pest of grains and corn. These two have been mentioned previously. Also there is the Clover-apple Aphis (*Aphis bakeri* Cowan) wintering on apple and summering on clovers, and *Phorodon humuli* alternating between plum and hop, chiefly injurious to the latter.

In a group containing those species whose summer hosts alone are of economic importance there occur several species; the Potato Aphis (*Macrosiphum solanifolii* Ashmead) is a pest of tomato, potato, egg-plant, cotton and lettuce; the Grain Aphis (*Macrosiphum granarium* Kirby) infests grains and grasses; both these aphids migrate to roses in the fall in temperate climates, but in the sub-tropical zone they may occur the year around on their summer hosts. In California they appear to feed and reproduce in the winter season both on rose and on the summer hosts. *Aphis cerasifoliæ* Fitch is a species which passes the winter season on choke-cherry and the warm part of the year on grains and grasses, and may be synonymous with *A. padi* Linn. *Aphis rumicis* which attacks many varieties of beans is said to winter on *Euonymus* in temperate climates. The parsley Aphis (*Rhopalosiphum capreæ* Kaltenbach) sometimes a pest on umbelliferous crops winters on willows: the Eastern Grape Aphis (*Macrosiphum illinoisense* Shimer) has been found to migrate in the fall to *Viburnum opulus*, whereon the eggs are deposited, to be followed in spring by a return migration to grape. In this group belong also the woolly aphids of beet, apple and pear, previously mentioned.

A third group contains those species whose winter hosts alone are economic plants. There are two wintering on saxifragaceous and six on rosaceous plants. The former are *Rhopalosiphum lactucæ* Kaltenbach, which migrates back and forward between Currant, Gooseberry and Sow-thistle (*Sonchus*), and *Myzus ribis* Linn. wintering on currants and migrating to and from *Stachys* and *Leonurus* of the Menthaceæ. The others are well-known pests of fruit trees; the Rosy Apple Aphis (*Aphis malifoliæ* Fitch) migrates between apples and rib-grass and plantains; the Black Cherry Aphis (*Myzus cerasi*) between Cherry and *Lepidium;* the remaining four winter on stone fruits, the Rusty Plum Aphis (*Aphis setariæ* Thomas) passes the summer on grasses, the Mealy Plum Aphis (*Hyalopterus arundinis* Fabr.) on reeds, the Reddish-Brown Plum Aphis (*Rhopalosiphum nympheæ* Linn.) on a number of water plants, chiefly liliaceous, and the Green Plum Aphis (*Aphis cardui* Linn.) on thistles.

Of the twenty-one species noted above at least fourteen, possibly fifteen or sixteen, are common to Europe and America.

Strictly European economic species with alternate host habits have not been discussed in this paper.

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PRESIDENT G. P. WELDON: Is there any discussion of this paper?

G. P. GRAY: The weeds which were mentioned in this paper as hosts of the aphids, brings up the question of the relation of weed control to insect control.

G. P. WELDON: Is Amaranthus a summer host plant of the rosy apple aphis? Bremner has reported in the Monthly Bulletin of the

California State Commission of Horticulture that he found an infestation on Amaranthus.

A. F. SWAIN: I think it was only an accidental infestation.

PRESIDENT G. P. WELDON: The next paper on the program is by H. J. Quayle, entitled "Cyanide Fumigation: Diffusion of Gas Under Tent and Shape of Tree in Relation to Dosage."

CYANIDE FUMIGATION[1]

DIFFUSION OF GAS UNDER TENT AND SHAPE OF TREE IN RELATION TO DOSAGE

By H. J. QUAYLE

The practical query "is there a better killing of scale insects secured at the top than at the bottom of the tree," in citrus fumigation, suggested the following experiments. More or less serious injury sometimes occurs in the top of high trees. If the dosage is reduced to avoid this injury, the question then arises as to the effectiveness of the reduced dosage in all parts of the tree.

Citrus trees vary considerably in shape from the low broad lemon tree to the tall narrow seedling orange tree. In one case the extreme may be a tree whose circumference is twice the distance over the top, while in the other the circumference and the distance over the top may be equal.

It may be possible to determine the concentration of the gas in different parts of the tent by chemical means, but this would be a tedious method and might be difficult to apply for the period of 45 to 60 minutes which would be necessary. Consequently, we chose to determine the concentration of gas in different parts of the tent by entomological rather than by chemical methods. This was done by determining the killing effect on insects placed in different parts of the tent.

Likewise the relation of the shape of the tree to the dosage was determined by a series of experiments in which the same amount of gas was generated under two tents representing the extremes in shape.

Form "trees" were constructed over which were placed ordinary fumigation tents of 8 ounce U. S. A. duck. The dimensions of the two trees were 31 ft. x 31 ft. and 22 ft. x 44 ft. They were thus fair sized trees, and the conditions were practically normal, excepting that there was no foliage under the tent. This point, however, has no bearing on the results, for comparatively the same conditions prevailed in both

[1] Paper No. 48. University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

tents. In the high tent the insects were placed in the center, one foot from the top, and one foot from the bottom. In the low tent they were similarly placed at the top and bottom, but not in the center. The gas was generated by the pot method.

Following is a summary of the experiments:

Fifty-two Experiments—Bean Weevil (*Acanthoscelides obtectus*)

Dosage, 5–20 oz. Exposure, 45–60 min. Tent temperature, 13°–24°C.

High tent 31 x 31			*Low tent 22 x 44*		
Place in tent	Number Insects	Killed (Percentage)	Place in tent	Number Insects	Killed (Percentage)
Top	237	65.8	Top	233	83.7
Center	237	70.8			
Bottom	231	35.5	Bottom	225	55.5
Totals	705	57.5	Totals	458	69.8

Twenty-two Experiments—Granary Weevil (*Calandra granaria*)

Dosage, 6–15 oz. Exposure, 30–60 min. Tent temperature, 17°–27°C.

High tent 31 x 31			*Low tent 22 x 44*		
Place in tent	Number insects	Killed (Percentage)	Place in tent	Number insects	Killed (Percentage)
Top	104	45.4	Top	105	47.6
Center	103	36.89			
Bottom	102	5.88	Bottom	105	19.04
Totals	309	26.5	Totals	205	33.3

Twenty-six Experiments—Bean Weevil

Sulfur, 1–7 oz. and Cyanide, 2–7 oz. Exposure, 50 min.

High tent			*Low tent*		
Place in tent	Number insects	Killed (Percentage)	Place in tent	Number insects	Killed (Percentage)
Top	125	63.2	Top	113	62.0
Center	115	56.0			
Bottom	113	34.6	Bottom	107	44.0
Totals	353	54.1	Totals	220	57.7

Twenty-one Experiments—Bean Weevil

Dosage, 10–18 oz. Exposure, 30–90 min. Temperature, 8°–24°C.

High tent			*Low tent*		
Place in tent	Number insects	Killed (Percentage)	Place in tent	Number insects	Killed (Percentage)
Top	120	90.0	Top	120	90.0
Center	120	85.0			
Bottom	120	75.0	Bottom	120	83.0
Totals	360	83.3	Totals	240	86.6

The query stated at the outset seems to be answered by the results of the above experiments, also the difference in killing efficiency between very high and very broad trees. In every case the high and the

low tents were charged at the same time, thus insuring a similarity of climatic conditions. The tents were of the same material and in the same condition, but as an additional precaution, they were interchanged.

The locations of the highest percentage killed are in the following order: Top of low tent, center of high tent, top of high tent, bottom of low tent, and bottom of high tent. With the exception of one set of experiments, more were killed in the top than in the center of the high

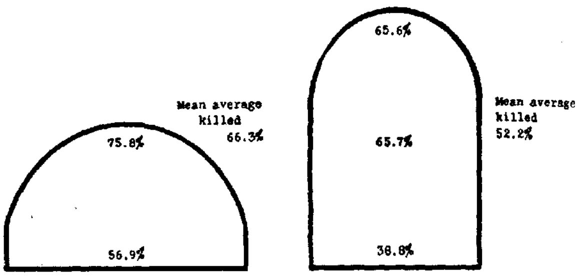

Fig. 11. Represents the summary of 121 experiments in which 2,873 insects were used showing the percentage of insects killed in different parts of the high and low tent and the mean average killed in each tent. The mean average of the high tent excludes the results in the center of that tent because no insects were placed in the center of the low tent, hence a more equable comparison.

tent, while in the totals there is a difference of only one-tenth of 1 per cent. While the difference in killing efficiency of the gas is not great between the center and top, there is a very great discrepancy between these locations and the bottom of the tent, a difference as shown in these experiments of 26.9 per cent. Likewise between the top and bottom of the low tent there is a difference of 18.9 per cent, and between the two tents there is a difference of efficiency, in favor of the low tent, of 19.4 per cent.

The fact that hydrocyanic acid gas is lighter than air, must account for a greater concentration accumulating in the top of the tents. The fact that the percentage killed is greater in the low than in the high tent, must be accounted for through the dosage schedules now in use, which do not adequately allow for the variation in the shape of the trees. We are not at this time, however, proposing any change in the schedules in practical use. Further extensive field experiments rather than laboratory calculations, must be the final test for any system of scheduling dosage. From the experiments here recorded which are field tests, the statement appears to be justified that our present

schedules are not correctly calculated for trees of extreme shapes. But from field experience, we are also aware of cases of unsatisfactory results on the insects with low broad lemon trees, and, on the other hand, complaints of too much injury to the tree in the case of tall orange trees. The discrepancy in our present dosage schedules for trees of different shapes has been pointed out by Woodworth, and he has proposed new schedules.[1] These schedules differ from the ones now in use chiefly in the fact that the larger trees receive a greatly increased dosage. This increase amounts in some cases to as much as 40 per cent, which dosage, the writer believes, cannot be used with safety to the trees in general practice.

Tabulation of Data Concerning the Form "Trees" Used in These Experiments

	High Tree 31 ft. x 31 ft.	*Low Tree* 22 ft. x 44 ft.
Tape circumference	31 ft.	44 ft.
Tent circumference	97 ft.	69 ft.
Tent surface	757 sq. ft.	380 sq. ft.
Ground surface	78.5 sq. ft.	154 sq. ft.
Total surface	835.5 sq. ft.	534 sq. st.
Volume	857 cu. ft.	717 cu. ft.

It will be seen from the table that the high tent is greater in volume by 140 cubic feet, and that the tent surface is greater by 377 square feet, the two factors that determine dosage. Consequently, the high tree should receive more cyanide than the low tree, but with our present schedules, these two trees receive the same amount of cyanide. This is partly because the basis of calculation is a geometrical figure corresponding to the shape of the tree, which does not take into account the variation in tent surface of differently shaped trees. The higher the tree, the greater, proportionally, is the tent surface when the tent is an octagonal sheet. The actual tent surface is determined by one dimension only, namely, the distance over the tented tree.[2]

In the high tree (31 ft. x 31 ft.) the circumference, as determined by the tape, or the geometrical figure, is 31 feet, but if the tape followed in and out of the folds of the same tent at the ground the distance would be 97 feet, or a difference of 66 feet. In the low tree (22 ft. x 44 ft.) measured in the same way, there is a difference of only 25 feet between the tape circumference and the actual tent circumference. Consequently, there is more tent area occupied by the folds in a tall narrow tree than in a low broad tree. Some of the folds may fit closely enough to prevent the entrance of much gas, but many of the folds

[1] Woodworth, C. W. New dosage tables. Cal. Agr. Exp. Sta. Bull. 257, p. 10-15. 1915.

[2] Morrill, A. W. Fumigation for the citrus white fly. U. S. D. A. Bur. Ent. Bull. 76, p. 39. 1908.

will be loose enough to allow the gas to diffuse between them. Thus the leakage surface is greater, and, moreover, the actual cubical contents is increased beyond that based on the measurement of a tight tape drawn around the tented tree.

The following "tent data" are presented to show the calculations for trees of widely different shapes. Examination of the table will show such variations as have already been alluded to in the case of the two trees mentioned, as well as further data regarding the surface of the geometrical figure, the ground surface, the relation of tent surface to volume, and the relation of dosage to tent surface and volume.

Tent Data

	Size tree	Dose[5] 100%	Tent[1] surface	Tent[2] volume	Rel. of dose[5] to surface and volume: Surface		Volume	Ground surface	Surface of[4] hemisphere and cylinder	Ratio of tent surface to volume	
a	10 x 16	3 oz.	79 sq. ft.	55 cu. ft.	1 oz. to	26 sq. ft. to	18 cu. ft.	20 sq. ft.	64 sq. ft.	1 to	.701
b	14 x 20	3	154	131	1	51	43	31	103	1	.851
c	16 x 28	4	201	248	1	50	62	62	153	1	1.232
d	18 x 36	5	254	394	1	51	79	103	206	1	1.542
e	20 x 24	4	314	300	1	78	75	45	187	1	.954
f	20 x 40	6	314	540	1	52	90	127	254	1	1.167
g	30 x 30	7	707	765	1	101	109	71	368	1	.541
h	30 x 40	9	707	1,176	1	78	131	127	454	1	1.665
i	30 x 60	13	707	1,850	1	54	142	286	572	1	2.618
j	34 x 50	13	908	1,950	1	69	150	198	622	1	2.147
k	38 x 40	11	1,134	1,686	1	103	153	127	614	1	1.486
l	38 x 64	18	1,134	3,188	1	63	177	325	834	1	2.811
m	40 x 50	15	1,257	2,546	1	83	170	198	773	1	2.026
n	40 x 60	18	1,257	3,396	1	70	189	286	873	1	2.704
o	42 x 44	14	1,385	2,259	1	99	161	154	748	1	1.631
p	44 x 68	22	1,520	4,492	1	69	204	367	1,076	1	2.954
q	45 x 60	20	1,690	3,971	1	79	198	284	1,022	1	2.497
r	49 x 54	25	1,886	3,878	1	75	155	232	1,058	1	2.056
s	49 x 68	25	1,886	5,413	1	75	216	367	1,245	1	2.870
t	50 x 60	23	1,963	4,687	1	85	203	286	1,172	1	2.386
u	50 x 76	76	1,963	6,461	1	67	223	459	1,375	1	3.290

O = Distance over.
C = Circumference.

[1] $O^2 \times .7854$.

[2] $\frac{C^2}{4\pi}\left(\frac{O}{2} - .144\right)$.

[3] $C^2 \times .07968$.

[4] $\frac{C^2}{2\pi} + \frac{CO}{2} - \frac{C^2}{4}$.

[5] On basis of 100% schedule now in general use.

Summary

The greatest concentration of hydrocyanic acid gas occurs in the upper half of tented trees.

The difference in the effect on insects at the top and bottom of a tree may be great enough to seriously impair the results. Little difference in gas concentration has been indicated by our experiments between the top and center of the tree.

Better killing of insects was secured in the low tent (22 ft. x 44 ft.) than in the high tent (31 ft. x 31 ft.). The actual difference was 19.4 per cent. These tents represent the most extreme shapes in citrus trees.

On the left are the two tents, representing the extremes in shape with which our experiments were carried on. On the right is a closer view of the high tent which shows the larger number of folds as compared with the low tent on the left.

Proportionally, there is more tent surface, and also volume, in a tall tree than a broad tree, and this is not indicated by the tape measurement around the tree, or by considering the tree as a fixed geometrical figure.

For practical consideration, the tall tree may well show more or less injury at the top to insure the insects being killed at the bottom.

PRESIDENT G. P. WELDON: Discussion of this paper is now in order.

R. S. WOGLUM: From observations in the field where the trees were more or less severely injured at the top, I am surprised that your experiments showed the same killing at the top as at the center.

H. J. QUAYLE: I think as a general rule there is a greater concentration of gas at the top than at the center of the tree, but that point was not brought out clearly in the particular experiments in question.

D. D. SHARP: I have seen some instances where the scales were not killed at the top of the tree, though it is a very common observation that more injury occurs at the top of the tree than elsewhere.

J. D. NEULS: In experiments in the fumigatorium, plants at the top of the fumigatorium seemed to be more injured than at the bottom.

PRESIDENT G. P. WELDON: The next paper is on "The Effect of Petroleum Oils on Mosquito Larvæ," by S. B. Freeborn and R. F. Atsatt.

THE EFFECTS OF PETROLEUM OILS ON MOSQUITO LARVÆ[1]

By STANLEY B. FREEBORN and RODNEY F. ATSATT,
University of California, Berkeley, California

To the layman, mosquito control immediately suggests oiling for since Dr. Howard's pioneer publications on the subject in 1892, the literature has been flooded with recommendations for the application of oil in order to control mosquitoes. Very few of these accounts suggest what grade of oil to use or the actual effect of the oil on the larvæ with the result that we have widely conflicting accounts of the amount of oil necessary to adequately control a given area, varying data on the time required for the oil to kill the larvæ, and no thoroughly satisfac-

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[1] The authors wish to acknowledge the helpful suggestions and kindly criticism of Prof. George P. Gray of the University of California.

tory explanation of the principles underlying its use. The public gradually drifted into the impression that the oil killed the larvæ by suffocation brought about by the formation of an impenetrable layer of oil on the surface through which the larvæ were unable to thrust their breathing tubes to get oxygen. With this idea in view most of the recommendations were based on the purely mechanical problem of getting an oil that would spread easily and be fairly permanent. It has been the practice of the entomological division at the University of California to recommend a half and half mixture of crude oil and kerosene which would form an oil having a Baumé reading of 28° to 32° and which was found to answer the mechanical requirements mentioned above. It was our idea to check this recommendation with laboratory methods to determine if possible if any other oils would be better suited for the purpose.

In order to determine an ideal oil it was necessary to know first how the larvæ were actually killed and this paper takes up that phase of the problem. Various suggestions have been advanced, and in order to satisfy ourselves and reach a conclusion of our own we attempted to check up these different theories.

In all our experiments the mosquitoes used were the full grown larvæ of *Culiseta incidens*, a common culicine mosquito of California that is widespread throughout the state and to be found breeding in situations of varied character.

The oils used were a series of standard commercial oils of California origin. Their trade names and Baumé readings were as follows: Crude, 15.4°; low grade stove distillate, 29°; high grade stove distillate, 33.3°; commercial engine oil distillate, 38.5°; kerosene, 39.7°; gasoline, 55.5°; and a by-product with a Baumé reading of 20.3°, called "still bottoms," a residuum obtained from the stills after distillation. Besides these so-called toxic petroleum oils we used a standard brand of the non-toxic liquid petrolatum of 27° B.

The several theories, including our own, which have been advanced in explanation of the lethal action of the petroleum oils upon the mosquito larvæ may be summarized as follows:

(1) The physical properties of the oil layer are such that the surface tension is "annulled" to the extent that the larvæ are unable to hold themselves to the surface for the necessary breathing period.

(2) The layer of oil acts as a definite mechanical barrier between the larvæ and the outside air and thus leads to their ultimate suffocation.

(3) A portion of the oil or some of its dissolved or suspended material goes into solution in the water and poisons the larvæ.

(4) The oil in entering the siphon and tracheal tubes blocks them and effectually impairs respiration.

(5) The oil on entering the siphon and tracheæ acts as a contact poison through a direct action on the tissues.

(6) The theory which we will endeavor to prove in this paper is that it is the oil vapor from the inspired oil through its extremely rapid penetration of the tracheal tissues, which produces the marked lethal effects.

(1) Surface Tension

Ross in 1911 suggested that the oiling of a water surface so changed the physical conditions that the "larvæ are no longer able to keep the surface by surface-tension and quickly drown." In all our observations in this laboratory we have noticed a marked contradiction to this theory in that the larvæ under a film of oil are very prone to remain at the surface for considerable lengths of time, either in a quiescent condition or in what seems a definite struggle to pierce the film. It is very true that in a small shell vial with a steep meniscus, the larva under a film of oil is unable to hold his relative position on the meniscus, but continually slides toward the apex of the concavity, but when the meniscus is less steep, there seems to be no difficulty in maintaining the position at the surface.

(2) Suffocation

Celli (1904) in discussing the various larvicides states that petroleum oils exert "a mechanical action only, that is, by intercepting the air from the larvæ." A simple experiment was conducted by us in which this theory was tested. Larvæ were placed in several tubes with equal volumes of the same water and a previously moistened small cotton plug introduced into each tube until the water rose a short distance above it. Thus an effectual mechanical obstruction was introduced between the larvæ and the surface air which could have no other effect than that for which it was intended. At the same time, larvæ were placed in the same volume of the same water and a thin film of kerosene poured on the surface. The rapid death of those larvæ under the kerosene (45 minutes) as compared with those which were kept from the air through a simple mechanical means (30 hours) shows clearly that since the time required for uncomplicated suffocation was so much greater than that which is required for death under a layer of oil, the possibility of suffocation is but a slight factor in the larvicidal action of the oils.

Another set of larvæ in tubes containing equal volumes of water were covered with films of the various oils in the series with which we

were experimenting. If there were none other than the "mechanical barrier" action on the part of the oils, all of these larvæ should have died at the same time. On the contrary, however, we find a great difference in time, ranging from 45 minutes under the kerosene to 3 hours under the crude oil.

Somewhat along this line McFie gives the account of an experiment in cutaneous respiration wherein he kept totally submerged larvæ of *A. calopus* alive for over twenty days, the only necessary factor seeming to be that the water should be running slowly. The evidence, therefore, seems quite sufficient for discarding the suffocation theory.

(3) Poisoning through Aqueous Solution

The idea that some portion of the oil may be dissolved or suspended to a slight extent in the water in which the larvæ are living and thus produce the toxic effects has been suggested.

In our experiments we proceeded somewhat as follows: A quantity of boiled water was placed in a large funnel, covered with a deep layer of kerosene and allowed to stand for four hours. At the same time, an equal volume of the same water was tightly sealed in a glass jar. At the end of this period the water that had previously been treated with kerosene was drawn off from the bottom of the funnel without disturbing the oil film and placed in equal amounts in six vials. Equal volumes of water were drawn from the sealed bottle of untreated water and placed in corresponding vials. One larva was introduced into each of the twelve tubes and the water was then sealed with hot paraffin. The average length of time during which the larvæ survived in the normal water was 25⅓ hours and the corresponding period for those in the kerosene treated water was 25⅓ hours showing rather definitely that the solubility of kerosene in water is not a toxic factor in the killing of larvæ by its application to the medium in which they live.

Quoting again from McFie in an experiment where he used *Mansonioides africanus*, a type particularly adapted for the purpose through its faculty for cutaneous respiration and its subsequent habit of remaining on the bottom of the container we find "a larva was kept in a jar of water to the surface of which crude kerosene . . . had been added. For three days it appeared to be unaffected and on the fourth day it pupated" thus showing no ill effects of the oil on the surface.

From these accounts it may be concluded that the efficiency of the kerosene as a larvicide is independent of its solubility in the water.

(4) Blocking of the Tubes

The effectual suffocation of the larva through the entrance of the oil into their siphons and the actual physical blocking of the tubes by its presence has been suggested by Ross (1902).

In experiments in which we allowed the mosquitoes to draw into their tracheal systems repeated doses of the oil, which we had previously colored with Sudan III, an oil soluble stain not soluble in water, we found upon dissection that the oil had thoroughly penetrated even to the finest branches of the tracheæ and had through its viscosity and capillary action almost completely collapsed the delicate walls of the larger tracheæ. In the smaller division of the respiratory system the intermingled drops of oil and bubbles of air filling the whole diameter of the tube could be plainly seen. There can be no doubt that the oil, no matter whether a light oil such as kerosene, or a heavy oil-like liquid petrolatum does flow into the anal siphon, the main tracheæ and into even the very finest subdivisions, and does this in sufficient quantity to completely block them and render the passage of air impossible.

Here we must preclude, too, any possible application of the suggestion of Schafer, concerning terrestrial insects, that it may be possible for them to continue to breathe after having inhaled a quantity of kerosene or other oils, due to the penetration of the oil by the respiratory gases, for in our experiments the mass of the oil is without question too great.

We will agree then that this form of suffocation of the larva, due to an effectual plugging of the tracheal tubes by the inspired oil, could be considered as a very potent factor in the efficiency of the larvicide if time were allowed for this mode of killing to take place. One set of larvæ which were shut off from the air surface by a layer of paraffine and another set which were shut off from the air by inhaling a quantity of non-toxic petrolatum which plugged their tracheæ, were found to live for approximately the same length of time, while larvæ with petrolatum and kerosene in their respiratory tracts showed a decided difference, the kerosene producing lethal effects in 45 minutes while the non-toxic petrolatum required 4½ hours.

As a further check upon this series of experiments and to show that the more rapid penetration of the kerosene into the tubes of the larvæ as compared with the slower penetration into the tracheæ of the heavier oils was not the primary cause of the difference in toxicity, it was repeated using the non-toxic petrolatum and a toxic petroleum oil of the same viscosity, and here again the toxic oil produced a much earlier death than the non-toxic petrolatum.

(5) The Oils as Contact Poisons

As we have shown above, by the use of our colored oils, these substances actually flow into the trachea and even into the very finest branches of the respiratory system, so that we have here a splendid basis for the conclusion that the oil in its close relation to the body

tissues of the larva would cause death by actual contact. Undoubtedly this factor of toxicity of the oils would suffice amply for the killing of the larvæ if sufficient time were allowed for it to act, but when a set of larvæ were treated with different oils, stained with Sudan III, in each case, except with the petrolatum and the crude oil, the larvæ were dead from an hour to two hours before the oils had penetrated the tissue as shown by the presence of stain in the microscopical examination. The oil enters and spreads throughout the tracheal system with great rapidity, but the larvæ, in our experience, are always dead long before the oil penetrates the tissue.

Shafer (1911) showed that in terrestrial insects treated with kerosene, penetration of the tissue required between three and twelve hours and concluded that death from treatment with kerosene resulted long before the liquid, as such, had time to penetrate the body.

Our next experiment gave further basis for this conclusion.

(6) The Oil Vapors as the Toxic Agents

Sen in 1914 reported a single experiment in which a few drops of kerosene were applied to a cotton plug in a bottle of water containing larvæ. He does not positively announce their early death as being directly caused by the vapor, but intimates that it is possible.

McFie (1917) repeated this experiment with different species of larvæ but remarks that its "action (the vapor) is less constant and much slower than that produced by a film of oil." It seems only reasonable to assume that the results would be much slower in this type of exposure than with a film of oil for with the film method the oil and its attendant vapors are brought in undiluted and direct contact with the respiratory tract, but when the oil vapors pass off from the saturated cotton in the vapor experiment they reach the larvæ in an indirect manner, highly diluted with air.

Since with our series of oils the lethal effects of the various grades corresponded very closely with the curve of their boiling points, we were led to believe that the volatility of the oils was the true index for their larvicidal action. With this point in view, we subjected our group of oils to the following experiments.

We placed samples of the series in small straight sided open pans and exposed them to a temperature of 28° C. ± 2°, in a constant circulation of air with the result that at the end of 103 hours the oils had evaporated to the following extent:

Kerosene	98.8%
Eng. distillate	85.2%
High grade stove distillate	35.4%
Low grade stove distillate	10.6%
Residuum	6.5%
Crude	.9%

We then used these evaporated residues to make the films in the usual manner and found that the practical toxicity or lethal effect of the oils had decreased in proportion to the percentage of the weight lost through evaporation, in other words, kerosene, previously giving rise to the greatest "lethality" had become the least efficient in its larvicidal properties which seemed to indicate that the loss of the volatile constitutents brought about a decreased toxicity.

Having obtained this data, we proceeded with a very definite check. Using shell vials of 2 x 5 cm. size, we placed several larvæ in equal volumes of their natural medium in each vial. Plugs of absorbent cotton were then introduced into the neck of each vial and on them were poured 3 cc. of the various oils, the lighter ones being colored with Sudan III in order to ensure the detection of any oil that might run down the inside of the vial to the surface of the water, and the vials corked up and sealed. A check, consisting of a similar vial containing larvæ, but to whose cotton plug there was applied no oil, was also used.

The results were as follows:

Vapors confined in chambers above water	*Average time required to kill larvæ*
Gasoline	153 minutes
Kerosene	185 "
High grade stove distillate	254 "
Low grade stove distillate	20 hours
Residium	*72 "
Crude	*72 "
Water vapor only (check vial)	*72 "

This experiment established the point that the vapors of the various volatile petroleum oils were toxic to mosquito larvæ even in dilute quantities when there was no possibility for the oil as a liquid to come in contact with them. As the curve of the time required to kill the larvæ in this experiment coincides with the curve of their volatility, the most volatile killing in the shortest time and also to the curve of the time required to kill when the oils were applied as films to the surface of the water, we feel justified in saying that the practical toxicity of the petroleum oils increases with their volatility. Of what these volatile products consist we are unable to state at this time.

We might call attention also to the fact that although we have suggested that volatility (a physical characteristic) may be taken as an index for the practical toxicity of the petroleum oils when used as larvicides, it must be borne in mind that the toxicity is entirely due to the chemical characteristics of the oils which vary with almost

* No apparent ill effects at end of 72 hours.

every distillation. Hence volatility as a factor in the toxicity of the oils enters into consideration because it serves as a measure of the amount of gaseous material given off in a given time and because the more toxic chemical constituents seem to be contained in the volatile fractions of an oil.

Although in all the petroleum oils having a boiling point below 250° C. the volatile constituents of the oil produce the lethal effects, those with the higher volatility producing the most marked and rapid results, in the oils having a boiling point higher than 250° C., the effects of the volatile constituents which are practically negligible in quantity may be overtaken by the effects of stoppage, actual contact, and even suffocation.

Moore (1917) working with terrestrial insects states that in volatile organic compounds the toxicity is correlated closely with the volatility but that a decreasing volatility is accompanied by an *increased* toxicity.

This would seem to be in direct contradiction to the results of our experiments but closer consideration of his findings suggests that the apparent discrepancy may be explained upon a difference in interpretation of the word "toxicity." From his point of view, a laboratory measurement of the total content of toxic elements was desired and possibly in no case was a saturated atmosphere of the chemical obtained. On the other hand, we were working to determine the toxicity of the oils under field conditions and in all our experiments we used a saturated atmosphere. In short, our object was to determine the oil which would give off the largest quantity of toxic material in the shortest length of time, while the experiments of Moore were designed to show the toxicity of definite amounts of the different chemicals exposed for a given period and confined in a given volume. Thus our standards of comparison were based on an entirely different viewpoint.

Again his results with petroleum oils seem hardly justifiable for his results are tabulated and his curves plotted in gram-molecules, *i. e.*, the molecular weights expressed in grams. Owing to the present impossibility of establishing the molecular weight of the petroleum oils it is difficult to conceive of an accurate measurement of these oils in gram-molecules.

In a later publication (1918) Moore tests out the toxicity of kerosene, again with terrestrial insects; but in some cases at least, using saturated atmospheres and concludes that "low boiling point fractions (highly volatile) are more toxic to insects in the form of vapor than high boiling point fractions due to the slight volatility of the higher fractions." He adds to this statement that "high boiling point compounds are more toxic than low boiling point compounds when used as contact insecticides in the form of an emulsion."

Inasmuch as we are confident that the oil vapors are the primary cause of death in the larvæ we feel that despite Dr. Moore's previous apparent disagreement with our findings this later publication seems to be in perfect accord with our results.

Conclusions

(1) The toxicity of the petroleum oils as mosquito larvicides increases with an increase in volatility, the more volatile oils producing the more marked lethal effects.

(2) The volatile constituents of the oils contain the principles that produce the primary lethal effects.

(3) The lethal effects are produced by the penetration of the tracheal tissue by the volatile gases of the oils.

(4) In the heaviest and least volatile oils (those having a boiling point greater than 250° C.) this action may be supplemented or apparently secondary to the effect of actual contact of the oil with the body tissue or perhaps to mechanical means such as suffocation or plugging of the tracheæ.

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President G. P. Weldon: Discussion of Mr. Freeborn's paper is now in order.

R. W. Doane: Do you find that the action of the valves of the anal siphons have any effect upon the manner by which the oil enters the tracheæ?

S. B. Freeborn: We have noticed repeatedly, when using stained oils, that the oil seems to pass into the anal siphon around the valves even though they be apparently tightly closed.

R. S. Woglum: Did you determine how long the oil of the different grades would remain on the water?

S. B. FREEBORN: We have not as yet conducted any evaporation experiments on films of water but we know from experience and from the results of our evaporation trials with different grades of oils that both temperature and air circulation have a marked effect upon the rapidity with which the oil disappears. In the case of our evaporation experiments we determined that a fan which kept the air in circulation in the incubator was responsible for 83 per cent of the evaporation for whenever the fan was shut off the evaporation decreased that percentage for the time the fan was out of commission. I should imagine from these results that air circulation would be a very potent limiting factor in nature.

G. P. GRAY: I am very glad to see articles on the use of petroleum oils appearing in the publications for it seems to me that work with this group will produce very satisfactory results for insecticide development. Much of the work yet to be done must be along chemical lines for although the physical characteristics act as indices and may augment or detract from the final toxic effects, it is after all the chemical constituents that actually do the work.

PRESIDENT G. P. WELDON: I will next call for a paper entitled "Notes on the Beet Leafhopper," by H. H. P. Severin and W. W. Thomas.

NOTES ON THE BEET LEAFHOPPER, EUTETTIX TENELLA BAKER

By HENRY H. P. SEVERIN, Ph. D., *California Agricultural Experiment Station* and WILLIAM W. THOMAS, M. S., *Spreckels Agricultural Experiment Station*

Ball[1] accounts for swarms of *Eutettix tenella* in the sugar beet fields of Utah in the spring of 1915, "by flights from the serious California outbreaks of 1914. This would involve the crossing of chain after chain of mountains and traveling from 600 to 800 miles in an air line."

In California, Ball found the leafhoppers breeding in abundance on the native Atriplex in the Lake Tulare region. He writes, "This district extends down as far as Bakersfield and the same conditions are probably repeated in suitable areas in the Mojave Desert and Death Valley sections. The leafhoppers were found commonly in the Imperial Valley, and it is probable that this whole region is within the permanent breeding grounds and is the source of the California troubles."

[1] Ball, E. D., 1917. Utah Agr. Exp. Sta. Bull. 155.

Although the senior writer was engaged in a study of the anatomy and histology of the internal organs of *E. tenella* as a foundation for the life cycle of the causal organism of curly-leaf of sugar beets if such occurs in the insect, we considered it our patriotic duty to temporarily abandon this phase of the problem, and spend a considerable amount of time in the field during the period of the war. Since Ball believes that the beet leafhopper breeds in arid or desert regions, and that the migration of enormous numbers of this pest have caused three serious and widespread outbreaks of curly-leaf in California and one in Utah in 1915, from flights of the California outbreaks in 1914, an investigation was started to determine where this insect spends the winter and to locate the breeding areas in this state. He states, "Any information by which the probable occurrence of these periodic outbreaks could be foretold would, therefore, be worth millions of dollars to this industry."

Trips have been taken into the San Joaquin Valley, to the Tulare Lake and Bakersfield district, Salinas Valley, Mojave Desert, Death Valley, Imperial Valley and to sugar beet fields in various parts of the state. After a general survey of the enormous territory, it soon became evident that it would require several years of field work before definite conclusions could be drawn in regard to the breeding areas of this insect. We shall, therefore, confine our attention to the results so far obtained in the Death Valley and Imperial Valley.

Death Valley

On January 27–31, a trip was taken into the Death Valley and sweepings were made on desert vegetation from Ryan to Keane Wonder, a distance of thirty-eight miles, and on cultivated vegetation at Furnace Creek ranch situated about midway between the two towns. No *E. tenella* were captured on desert vegetation; such as cattle spinach (*Atriplex polycarpa*), desert holly (*A. hymenelytra*), alkali blite (*Suaeda moquini*), creosote bush (*Larrea divaricata*), mesquite (*Prosopis juliflora*) and other undetermined plants. No beet leafhoppers were caught on salt grass (*Distichlis spicata*), Kern greasewood (*Spirostachys occidentalis*) and salt rush (*Juncus leseurii*) growing near the margin of the salt marshes. No specimens were taken on mesquite, arrow-wood (*Pluchea sericea*) and Bermuda grass (*Cynodon dactylon*) growing along Furnace Creek. No hoppers were captured under cultivated conditions at Furnace Creek ranch on alfalfa, cheese weed (*Malva parviflora*), nettle-leaf goosefoot (*Chenopodium murale*), Bermuda grass, and on arrow-wood and Bermuda grass growing along the irrigation ditches. If we are justified in drawing conclusions from the investigations carried on at this time of the year, apparently *E. tenella*

does not occur on desert vegetation from Ryan to Keane Wonder and in the cultivated area at Furnace Creek ranch in the Death Valley.

Imperial Valley

In view of the fact that the same territory must be covered repeatedly during a year, we have selected the Imperial Valley for more intensive work. Up to the present time the investigation has been carried on under desert and cultivated conditions and no attention has been given to the canyons, foothills and mountains.

Ball suggests that the flights of the beet leafhopper may be "in the nature of migrations northward in the spring and southward in the fall." If our interpretation of this statement is correct, we would expect to find the hoppers wintering over in the desert after their southward flight. Under desert conditions, however, only a few specimens were captured on the foliage of the following plants:

January 22, 1918, 3 *E. tenella* on gourd (*Cucurbita californica*), 4 miles west of Coyote Well near foothills.

March 10, 1918, 2 *E. tenella* on creosote bush (*Larrea divaricata*), 4 miles west of Coyote Well near foothills.

The beet leafhopper was extremely scarce at this time of the year on vegetation in desert areas within cultivated districts. Sweepings on desert vegetation in the vicinity of the Alamo River near Holtville, and the New River near Seeley and Brawley (Map[1]), and also on vegetation growing along the banks of these rivers, captured only an occasional specimen.

An investigation was made at the boundary between the desert and cultivated area. A glance at the map shows that a main irrigation canal marks the boundary between the desert and cultivated land on the west side of the Imperial Valley. Between the San Diego and Arizona railroad tracks and the State Highway, desert collecting was started about one mile west of Dixieland and continued to the irrigation canal but not a single specimen was captured. Near the irrigation canal and in recently irrigated fields over one hundred adults and thirty nymphs were collected on the lowland or sea purslane (*Sesuvium sessile*) on March 13–14. In the same vicinity a dozen hoppers were taken on Chinese pusley (*Heliotropium curassavicum*).

In January and March *E. tenella* was found in large numbers under cultivated conditions in all localities visited in the Imperial Valley on the Australian salt bush (*Atriplex semibaccata*), a native plant of Australia. During a hot sunshine, sweepings on this plant near Calipa-

[1] The map is one issued by the Automobile Club of Southern California. It was not reproduced. Ed.

tria, Brawley, Imperial, Dixieland, Seeley, El Centro and Holtville (Map) rarely failed to capture from one to fifteen adults. In taking the trip by stage to the various towns mentioned, the Australian salt bush was observed growing along irrigation ditches, roadsides, railroad tracks, fences and vacant fields. Several hundred specimens were captured on a half dozen patches of this Atriplex and yet day after day when these same plants were swept with an insect net, more and more bugs were obtained. In all probability, many millions of beet leafhoppers occur on this plant in the Imperial Valley.

Specimens of the Australian salt bush in the University of California herbarium show that the plant occurs in the following counties of California: Nevada, San Mateo, Los Angeles, Orange, Riverside and San Diego. In Orange County, three miles northeast of Huntington Beach, forty-two *E. tenella* were captured on Australian salt bush on January 21. A few specimens were also caught on *Malva parviflora* and *Chenopodium murale*. Several old beets showing curly-leaf were found in the same vicinity, although this disease has never been reported from Orange County on the authority of Professor R. E. Smith.

Hibernation. In the Imperial Valley the beet leafhopper cannot strictly be said to hibernate, understanding by that term the passing of the winter in a greater or less degree of torpor, without food. During the winter few specimens were captured during the early morning hours due to the sluggishness of the insects produced by the cold nights; also on cloudy days but few bugs were taken. That the adult hoppers do not undergo a fast during the winter is shown by the following experiments: On February 24, at 6 p. m., ten *E. tenella* were placed without food in a cage with top and sides made of sheer muslin. All died within 1½ days under field conditions at a maximum temperature of 86° F. and a minimum temperature of 42° F. This experiment was repeated, but the insects were placed in a cage without food at 8 a. m. Six died within ten hours and all were dead at the end of one day (maximum temperature, 84° F.; minimum temperature, 36° F.). In a similar experiment, ten specimens placed in a cage without food at 8 a. m. died within 1½ days (maximum temperature, 84° F.; minimum temperature, 34° F.).

Besides the plants already mentioned in this paper, *E. tenella* was captured on the foliage of the following plants in various localities in Imperial County:

Quail brush (*Atriplex lentiformis*), 3 miles south of Imperial, January 23, 1918.
Cattle spinach (*A. polycarpa*), 2 miles east of Dixieland, March 14, 1918.
Shad scale (*A. canescens*), Holtville, January 23; Niland, March 15, 1918.
Alkali blite (*Suæda moquini*), Niland, March 15; Dixieland, March 13, 1918.
Bermuda grass (*Cynodon dactylon*), 2 miles south of Imperial, January 23, 1918.

Tall pepper grass (*Lepidium medium*), 3 miles south of Imperial, January 23; Calipatria, March 15, 1918.

Cheese weed (*Malva parviflora*), Calipatria, March 15, 1918.

Poverty weed (*Iva axillaris*), Calipatria, March 15, 1918.

It may be possible that the beet leafhopper was not feeding on all of the plants listed, but that the vegetation simply served as a resting place. Near Manteca, on February 11, a single adult was captured on bamboo which served as a wind break. The foliage of bamboo was swept with an insect-net during an entire afternoon but not another specimen was taken.

During the winter in the Imperial Valley, nymphs of *E. tenella* were found on the lowland or sea purslane (*Sesuvium sessile*), Australian salt bush (*Atriplex semibaccata*) and nettle goosefoot (*Chenopodium murale*). Nymphs collected on the Australian salt bush at El Centro on January 22, transformed into adults on January 30. To determine whether eggs had been deposited on *Sesuvium sessile* and *Atriplex semibaccata* under natural conditions, pieces of the plants were shaken over a black back ground at intervals for several days so that there was no question of doubt that neither an adult or nymph was present on the vegetation. The plant was then placed in a card board box with a hole at one end opening into the mouth of a phial. For a period of ten days, nymphs hatching from eggs deposited in both species of plants were found in the phials.

Conclusion

In the cultivated districts of the Imperial Valley, *E. tenella* has been found in large numbers on the Australian salt bush (*Atriplex semibaccata*) in January and March, and the lowland or sea purslane (*Sesuvium sessile*) in March. The pest is breeding on these two plants under natural conditions. No complete hibernation occurs in the Imperial Valley.

We are deeply indebted to members of the botanical department of the University of California for the determination of the plants mentioned in this paper.

President G. P. Weldon: The next paper is entitled "Some Problems in the Control of Insects in Stored Foods in California," by R. W. Doane.

SOME PROBLEMS IN THE CONTROL OF INSECTS IN STORED FOODS IN CALIFORNIA

R. W. DOANE, *Stanford University*

The critical situation in which we find ourselves at the present time, particularly as regards the food that we need for our allies and ourselves, strongly emphasizes the necessity of taking every step possible to prevent the loss of foods or food materials.

The entomologists have been keenly aware of the importance of insects in this struggle for food, and since the very beginning of the war have been trying to bring before those in authority and before the people in general the important facts bearing on this subject. As a rule we have met with a hearty response when we have called for action along certain definite lines, but we have also met with disappointments, for it is sometimes very hard to convince the uninitiated that things as small and lowly and despised as insects can play an important part in this great world war.

But when one finds a mass of flour and excrement matted together by the webbing made by the larvæ of the Mediterranean flour moth, or when one finds the dark ill-smelling flour beetles in the flour, or the weevils or their larvæ in the rice or beans or other food products, it is not hard to convince the observer that something is wrong, and all agree that something should be done to correct this disagreeable state of affairs.

Here in California where many insects breed throughout the year, we have paid but little attention to the insect pests of stored foods. Twenty-five years ago Prof. W. G. Johnson, at the time an instructor in Entomology in Stanford University, did a good deal of work with the Mediterranean flour moth in the mills around San Francisco Bay and a little attention has been paid to the larvæ found in stored fruit. But little other work has been done.

In a very hurried survey that we have made of about 100 warehouses and flour mills in Central and Southern California, while acting as consulting entomologist for the Federal Food Commission for California, we have found practically all of the common pests of stored foods in greater or less abundance. The Mediterranean flour moth is found in nearly all of the flour mills and is regarded by all as the most serious pest that we have to deal with in such places. The larvæ spin their silken threads wherever they go, and as they go everywhere, all of the machinery, the elevators and shoots, as well as the flour in the bins and sacks, become covered or filled with masses of webbing which cause no end of trouble for the miller.

The Mediterranean flour moth is also the most common pest of warehouses. In several instances we have seen hundreds of sacks of flour covered with the fine web that is spun by the larvæ as they wander about seeking a suitable place to pupate. These same sacks would be punctured with holes made by the larvæ as they came out and little heaps of flour on the sack indicated where other larvæ were working. In one warehouse nearly 1,000 sacks were thus seriously infested and about 2,000 other sacks showed only lighter infestation. The most seriously infested lots in the warehouse were those that had been in there for several months but one lot of nearly 500 sacks that had been in the warehouse only two weeks was heavily infested and the larvæ were issuing from the sacks in great numbers. This lot was, of course, badly infested before it came into the warehouse.

Fortunately the conditions in this warehouse were not typical of those found in most of the others visited. In one other instance we found 2,300 sacks of flour quite badly infested, but as a rule only smaller lots were found to be badly infested and in many warehouses we found very little or no infestation.

The rice weevil, *Calandra oryza* L., was found in great numbers in some warehouses and was present in smaller numbers in many other places. The heaviest infestation was found in a corner of an upper floor of a warehouse that was otherwise in fine condition. The beetles were first noticed crawling over sacks of flour stored near a window. Then it was found that the floor near this window was literally covered with the beetles and many were also found crawling over bags of imported rice in the end of the warehouse.

The source of this trouble was, after a long search, found to be a small, old, and evidently forgotten lot of rice stacked back of a larger lot that quite hid it. The bags were completely covered with the beetles and the floor and nearby bags of rice were also covered with masses of weevils that moved about slowly when the flashlight was turned on them.

In another warehouse little heaps of flour on a number of sacks indicated the presence of some insect. Further examination showed that inside the sack back of each of the little piles of flour, one of these rice weevils was working. A few holes were found showing where the weevils had issued from the sacks and some of them were found crawling about. Three lots of flour in different parts of the warehouse were found to be thus infested. Later it was found that these three lots, representing different brands of flour, had all come from the same mill and the source of the infestation will doubtless be found in the mill. Other lots of rice and a few lots of wheat were found to be infested with this pest.

The granary weevil, *Calandra granaria* L., was found in probably half of the warehouses visited, but usually only in small numbers.

The saw-toothed grain beetle, *Silvanus surinamensis*, is commonly found associated with this species and in some instances they both become very abundant and destructive. One warehouse that had suffered very severely from the attacks of these two pests in 1917, was still badly infested. Certain lots of waste grain and chaff were alive with these beetles and some of the large bins that were filled with barley were badly infested. As some of this barley was being moved from one bin to another it was passed over a screen and the screenings were found to consist largely of these beetles. In another instance all of the corn in a feed store was found to be badly infested with these two beetles. The confused flour beetles, *Tribolium confusum*, were found in nearly all warehouses and in some of the mills. Usually they were not present in great enough numbers to be of much importance but in some places they were causing much trouble and loss. They are general feeders, nearly all kinds of food products being attacked.

The rust-red flour beetle, *T. navale* Fab., was also found in a few places. Their presence gives the food a disagreeable, musty odor. Bread made from flour that has been infested with these beetles, has a disagreeable odor when first baked, but this all or nearly all disappears as the bread cools.

A few other moths and beetles, some of them as yet unidentified, and a mite, probably *Tyroglyphus longior* Ger., have been found in various cereals or cereal products in mills, warehouses, stores and private houses, but no attempt will be made to give a list of these now, as the inspections that we are still making keep bringing to light new and interesting forms.

We have found but a few instances of weevil infestation in beans, but when these occurred the loss was almost or quite complete. Adults of the third generation are now, March 25, appearing in lots of beans that have been in my laboratory since November.

But the important question of "What can we do about it?" is the chief concern of the miller, the warehouse manager, the storekeeper and the housewife, and of course therein lies our chief interest in these investigations.

Preventive measures are usually of first importance in dealing with any insect. In the case of these pests, particularly, too much emphasis cannot be placed on the importance of cleanliness and a careful watch of all incoming material.

Cleanliness will not always insure freedom from attack by the insect pests of stored products, but, in spite of certain notable exceptions, the rule holds that the amount and extent of the infestation bears a very

close relation to the degree of cleanliness about the mill or warehouse or store-room. Some of the best mills keep their machinery and floors and walls quite free from flour dust by using compressed air for cleaning out the cracks and crevices, blowing the dust out where it can be easily swept up by brooms. Others make a practice of treating their floors at regular intervals with gasoline or kerosene to destroy the larvæ and beetles and mites that accumulate in the cracks in all but the very best of floors.

Light is always a great factor in cleanliness and modern mills and warehouses are now built so that all parts of the house may be well lighted and of course daylight is preferable to any kind of artificial light. The claim is sometimes made that insects will not breed in food materials that are stood in light places. While it is true that insect pests are usually less common in such places, the rule is not a safe one in practice, for light does not altogether protect foods from infestation. Indeed, it seems that, while as a rule these insects prefer to work in dark places, they may under certain conditions, probably at breeding time, seek out the light. I have already referred to the swarms of rice weevils that had gathered to the light near a window, when the infested material from which they came, was near the middle of a long room with light only at the ends. Many other instances might be cited where not only the weevils but the moth larvæ were found in material stored in places where the light was good and strong.

Given a good, clean, light warehouse or mill, the careful manager will watch with unceasing vigilance everything that comes into his house. There are certain signs that usually betray the presence of insects to the careful observer, even when the food material is packed in sacks and boxes, and if there is any reason whatever for believing that incoming goods are infested, a careful examination must be made. Used sacks are particularly dangerous sources of infestation and should always be looked on with suspicion and thoroughly cleaned or fumigated before being admitted to the storeroom.

But in spite of all our care, infested materials may be carried into even the cleanest of places, or the adult insects themselves may fly or crawl in. In the same way some of the most important insect pests of our farms and orchards have escaped the watchful eye of the quarantine officer, and in both instances active control measures soon become necessary.

In a clean well lighted place, it is usually easy to detect the beginnings of an infestation which may be checked before it has spread far, but which, if left alone, would soon become of much more importance. A lightly infested lot of flour or meal may be sifted or rebolted and put in clean sacks with but little loss if the material is in a mill or can be

sent to one. If it is not possible to attend to this at once, or if it is necessary to move the infested material from one place to another, it is worth while to first clean the outsides of the sacks or other containers, in order that the insects may not be spread about in the moving.

The managers of some mills believe they have taken sufficient precautions to prevent the spread of the Mediterranean flour moth when they place infested lots of flour some distance away from other flour. One warehouse man told me that when he found any food stuffs infested with insects he always put a ring of hydrated lime around the infested lot to prevent the spread of the pest to other parts of the house. Another man was found to be using formaldehyde for fumigating a room badly infested with rice weevils and he could not understand why the beetles kept spreading.

Such "protective" measures are dangerous, not only because they do not kill the insects, but because they either give the experimenter a false sense of security or else he becomes discouraged and gives up altogether.

It is an easy matter for us to carry on a series of experiments with these insects, and to find that under certain conditions, that we have well under control, we can kill all or nearly all of the pests with which we are working. But as soon as we get out into the warehouses and mills, we begin to meet with serious difficulties. Let me give a concrete example: The warehouse previously referred to, where 2,000 or 3,000 sacks of infested flour was found, also had about 20,000 other sacks that were infested very lightly or not at all. This flour belonged to some twenty-seven different owners and was scattered throughout the warehouse. Stored with the flour, or close to it, was to be found many other kinds of food stuffs. Some of the owners of the flour believed that the warehouseman should fumigate his house and kill the insects, others objected because they were afraid that the flour or other foods might be injured by being fumigated.

The manager was told that the Board of Underwriters had said that anyone fumigating with carbon bisulphide would do so at his own risk, as his insurance would not cover the risk from fire if he had such materials in his house. On account of the danger to foodstuffs containing a great deal of moisture he could not use cyanide and the house was not tight enough for fumigating purposes anyway. There was no provision for heating the house by steam or otherwise. What should the poor man do? While he was seeking an answer to this question, the condition of the badly infested flour was called to the attention of the Pure Food Inspectors of the Bureau of Chemistry. They ruled that much of it was unfit for human food and the owners agreed to sell the most of it for stock food or for making paste for bill-posting purposes, and to reprocess the rest and thus save as much as possible.

This is only one, fortunately the worst one, of many troublesome cases we have had to deal with since beginning these inspections. As long as the insurance men refuse to take the fire risk when carbon bisulphide is used, I can only recommend the use of that important insecticide in small detached buildings or in places where no insurance risks would be involved. The managers of some mills and some warehouses tell us that they fumigate regularly with hydrocyanic gas, but often when talking with the foreman of such a place, we find that the work has not been done as often as reported and sometimes we find that it has really not been done at all. So it is very hard to get exact data on the amount of this work that is actually done. Those who are using this gas, or report that they are using it, say that they do not regard it as dangerous in mills or in warehouses where only cereals or cereal products are stored. But the Pure Foods Laboratory of the U. S. Bureau of Chemistry, when asked if there could be any danger from this source, ruled that there might be danger at least when other food products were present in the building.

Mr. De Ong, who has been associated with me in some of this work, planned to make a series of experiments in order that we might know definitely the answer to some of these questions but he is not yet ready to report.

We found only one mill where provision was made for using heat for fumigating. In this mill a small room, about 8 x 10 ft. with a 12 ft. ceiling, was provided with a large radiator and the miller told me that he could easily maintain a temperature there of 130° to 140° F. for several hours. In this room he places the infested packages of cereals that are sent back from the wholesalers and the retailers and subjects them to these high temperatures with the result that all the insects are killed. Materials only slightly infested can be reprocessed and the others can be used for stock food and the danger of the insects spreading over the mill is eliminated.

I have strongly recommended the construction of such fumigating rooms in many other mills and in some warehouses, where steam for heating was available. The room for such a purpose need not be a large one for if the lot of material to be treated is more than can be stood in the room at one time, it can be divided into small lots and the process repeated as many times as necessary.

The very interesting and important question as to whether the excretions of the insects, while they are in the flour or other food products, has any harmful effect on the food, keeps coming up constantly. It has been very generally assumed that if the insects can be removed the food will be perfectly wholesome. Few of us, however, can anticipate with any great pleasure the using of flour that has been infested

with any of these insects, even if it has been sifted or thoroughly rebolted before being used. The ordinary sifting removes all of the insects, at least all of the larger ones, but it unfortunately does not remove all of the fecal matter. Only rebolting will do this. Some believe that this fecal matter may contain enough poison to affect more or less seriously anyone using such contaminated flour. Others, and among them some prominent chemists and toxicologists, do not think any harm whatever could come from using bread made from even badly infested flour.

I am told that the results of some recent experiments seem to indicate that the poison, if any is present, may be due to the urates of the insects infesting the grain or flour. Cleaning the grain or sifting or even rebolting the flour would not remove the danger from this source, if it really exists.

This seems to be a subject worthy of further investigation and a chemist and an entomologist working together might be able to obtain some interesting and valuable results.

President G. P. Weldon: This paper by Professor Doane is now open to discussion.

R. E. Campbell: Is the HCN gas collecting in moist fruit products a real or an imaginary danger?

R. W. Doane: There seems to be some claim in fact for such a statement.

G. P. Weldon: How much material is necessary?

R. S. Woglum: Three ounces to 1,000 cubic feet has been recommended in a publication by Chittenden. Experiments carried on some time ago at Kansas Station included analyses and baking qualities of the product after fumigation.

G. P. Gray: I have gone into the records of the Kansas Station and as I recall there is no definite statement about flour absorbing HCN. While I believe there is no danger, still it is a matter that must be seriously considered.

H. T. Fernald: There would be a difference whether or not the product is cooked after fumigation.

R. E. Campbell: It seems to me there is possibility of developing in this connection insect proof containers.

H. J. Quayle: I am sorry that I did not hear all of the paper, but it seems to me the question of penetration is important in this connection, and as I understand it carbon bisulphide penetrates such material as grain and the like better than hydrocyanic acid.

G. P. Gray: The objection on account of danger of using carbon

bisulphide in warehouses might be overcome by having a special room constructed outside the warehouse.

R. W. Doane: I recommended such a course in the case of a warehouse I visited a few days ago.

President G. P. Weldon: The next paper in order is "Fumigation Experiments: The Time Factor," by A. F. Swain.

FUMIGATION EXPERIMENTS: THE TIME FACTOR

By A. F. Swain, *University of California, Citrus Experiment Station, Riverside, California*

Introduction

The control of the insect pests of citrus trees in California is accomplished largely by the use of hydrocyanic acid gas. As practiced at the present time, there is a considerable variety in the methods of procedure, and there are many problems on which further data are desirable. Among these is the determination of the proper time of exposure; whether the times in most common use, namely, 45 and 60 minutes, are the most practical; whether a shorter period would suffice or a longer period be more efficient; and whether there is any real difference in the efficiency between the 45 and 60 minute periods.

While carrying on some fumigation experiments for another purpose during the season of 1916–1917, the writer was impressed by the fact that there did not seem to be any constant and appreciable difference between exposures of 45, 50, and 60 minutes. However, as these experiments were not arranged for the determination of that factor, no certain results could be obtained therefrom. During the past season the problem again came up, and the writer made a few experiments in an attempt to add further data to the question. In this paper are given the results of those experiments, together with the results of actual commercial fumigation, as carried on in 125 groves in Tulare County during July, August and September, 1917, for the control of the citricola scale (*Coccus citricola*).

Experimental Fumigation

The necessary apparatus for the carrying on of these experiments consisted of the following. Two form "trees" of the same size and shape were used. These consisted of frameworks of such form that when covered with a tent they would approximate the shape of a fair-sized orange tree. Each measured 26 feet around by 31 feet over, which size requires, according to the schedules in use at present, a six ounce charge of sodium cyanide for the 100 per cent or full schedule. They were each covered with tents of the same size and material; namely,

45 foot, 8 ounce U. S. army duck. The ordinary earthenware fumigation pots and the form of sodium cyanide known as "Cyanegg" were used to generate the gas.

The methods of procedure were identical in each case. Small circular cardboard boxes (the common coverglass boxes), with the ends replaced with pieces of fine cheese cloth were used as containers for the insects. One was hung in each tent, about midway between top and bottom, and half the way from the center of the tent to the side. In those cases where red scale was used, the infested lemons were placed in a wire basket which was hung in the same position as the cages. The pot was set as near the center of the tent as possible, and the charge generated therein. Both "trees" were charged at the same time, although of course the insects from one were removed before those from the other. Although the "trees" were of the same size and shape, and the tents of the same material, the charges were alternated in each case in order to insure against any possible difference between them.

In many of the experiments during the past season adult lady bird beetles (*Hippodamia convergens*) were used as an index for the "killing efficiency." For many purposes these were more advantageous than scale insects, but as results with scale insects were wanted, they were used to verify the results obtained with beetles. The beetles were used because it was easy to determine whether or not they were alive, inasmuch as they are active insects; because this could be determined accurately within a comparatively few hours after fumigation; and because a considerable number of them could be obtained from the nearby mountains. All of the beetles used throughout the experiments were taken from two colonies in San Antonio Canyon near Camp Baldy. The main disadvantage with the beetles was the fact that they seem quite sensible to fluctuations in temperature. However, as each set was carried on at the same time and under identical conditions, this was immaterial. The scale insect used to verify the results with beetles, was the common red scale of citrus (*Chrysomphalus aurantii*) on lemons from the Hewes Ranch near El Modeno, Orange County.

In the experiments with the beetles four ounces of sodium cyanide were used in each charge, this being found sufficient to kill a large percentage of the insects. A complete killing in any case was not desirable. With the scale insects it was found that a 2½ ounce charge was sufficient, a 3 ounce charge sometimes making a complete kill. Inasmuch as these "trees" called for a 6 ounce dose at the full schedule, it must be noted that these experiments were carried on in the day time, and that these "trees" were not filled with foliage as is the case in the field.

The results of the fumigation work in Tulare County were obtained from reports by Commissioner C. F. Collins of Tulare County. Every year he has had an inspection made of each grove, and leaves collected from many of the trees, about a month or a month and a half after fumigation. The insects on these leaves are counted, the number present and the number alive being noted. As about 1,600 insects are examined from each ten acre grove, a fair estimate of the percentage killed is obtained. The figures in Table III were obtained from the 1917 report by Commissioner Collins.

TABLE I—*Hippodamia convergens*, NOVEMBER 19–23, 1917

Time of exposure	Number of lots	Number of insects	Percentage killed[1] Mean	Standard deviation	Percentage difference
60	10	632	97.47± .82	2.99± .58	
					11.00±2.53
30	10	702	86.47±2.39	8.67±1.69	
60	6	374	95.19±2.72	8.69±1.31	
					4.23±3.75
45	6	177	90.96±2.58	8.25±1.24	

These few experiments show a decided difference in favor of the 60 minute exposure over the 30 minute exposure. In ten lots, totaling 1,332 insects, the difference is 11.00±2.5 3per cent, which is fairly definite inasmuch as the difference (11.00 per cent) is more than four times as great as its probable error (2.53 per cent). However, in six lots, totaling 551 insects, the difference in favor of 60 minutes over 45 is but 4.23±3.75 per cent. This means that there is no real and constant difference, inasmuch as the probable error of the difference (3.75 per cent) is almost as large as the difference (4.23 per cent).[2]

After obtaining these results it was decided to repeat the experiments using lemons infested with red scale (*Chrysomphalus aurantii*) instead of the coccinellid beetles. Table II shows these results.

[1] The mean percentage killed is obtained by dividing the total number of dead insects by the total number used; $\frac{D}{T}=M$. The standard deviation (σ) is an index of variability and is obtained by the formula $\sigma=\sqrt{\frac{\Sigma\frac{D^2}{T}}{\Sigma T}-M^2}$. The probable error of the mean is an index of the reliability of the mean. It is obtained from the standard deviation and the number of experiments. The formula is $E_M=\pm 0.67449\frac{\sigma}{\sqrt{N}}$ (when N = the number of experiments).

[2] The probable difference between two means (A_1 and A_2) is: $A_1-A_2\pm\sqrt{E_1^2+E_2^2}$ (Davenport, C. B. Statistical Methods, p. 15, 1914). In the case of the 45 and 60 minute exposures it is therefore: $95.19\%-90.96\%\pm\sqrt{2.72^2+2.59^2}=4.23\pm3.75\%$.

TABLE II—*Chrysomphalus aurantii*, FEBRUARY 19–20, 1917

Time of exposure	Number of lots	Number of insects	Percentage killed[1] Mean	Standard deviation	Percentage difference
60	8	800	91.50± .36	1.50± .22	
					11.25± .77
30	8	800	80.25± .68	2.86± .43	
60	10	1000	96.30± .36	1.68± .26	
					0.40± .55
45	10	1000	95.90± .41	1.92± .29	
60	10	1000	87.30± .48	2.24± .34	
					0.30± .67
90	10	1000	87.60± .58	2.73± .42	

The experiments with the red scale as the index gave results quite comparable with those in which the coccinellids were used. Between 60 and 30 minute exposures there was a difference of 11.25±0.77 per cent which is comparable with that of the coccinellids; namely, 11.00±2.53 per cent. Between 60 and 45 minutes the probable difference was 0.40±0.55 per cent. In this case the probable error of the difference was larger than the difference, showing that there is no real difference. In addition to these, a series of experiments was carried on in which the exposures were 1 and 1½ hours, with the result that the difference in favor of the 1½ hour period was only 0.30±0.67 per cent. In other words there seems to be no advantage in an exposure of 1½ hours over that of an hour. Nor is there any higher efficiency obtained by an hour exposure than by a 45 minute exposure. There is, however, a decidedly higher killing efficiency obtained in 45 minutes than in 30 minutes. These experiments, therefore, show that at 45 minutes a killing efficiency is obtained which is not exceeded, by even twice that length of time.

COMMERCIAL FUMIGATION

To further verify these results, a study of the fumigation reports from Tulare County for the season of 1917 was made. Table III shows these results.

TABLE III—FIELD FUMIGATION, TULARE COUNTY, JULY–SEPTEMBER, 1917. *Coccus citricola*. 120 PER CENT SCHEDULE

Time of exposure	Number of orchards	Number of acres	Number of insects	Percentage dead
45	15	185	34,495	99.32
50	33	455	65,007	99.28
55	77	1225	192,908	99.21

[1] In determining the percentage of the insects killed only mature females were counted; the immature females and the males being omitted.

These counts show that there was no difference between the results obtained in actual field practise in Tulare County between exposures of 45, 50, and 55 minutes. The writer did not attempt to calculate the probable error and probable difference in these counts, as the percentage dead of the various exposures are so close that it is certain the probable error of the difference would be greater than the difference.

Summary

From a series of 44 experiments (using a total of 7,485 insects) carried on in the daytime under form "trees" covered with tents of 8 ounce U. S. army duck, with both coccinellid beetles (*Hippodamia convergens*) and red scale (*Chrysomphalus aurantii*), it was shown that an exposure to hydrocyanic acid gas for 30 minutes was not sufficient to obtain the highest killing efficiency. It was shown, however, that with 45 minutes as good results were obtained as with 60 and 90 minutes. From an examination of the results of commercial fumigation against the citricola scale (*Coccus citricola*) in 125 groves in Tulare County during the 1917 season, it was learned that there was no practical difference between the killing efficiency of the hydrocyanic acid gas with exposures of 45, 50 and 55 minutes.

Conclusions

It may be concluded from these experiments that an exposure of 45 minutes is sufficient to kill the red scale, under the conditions as given. It is possible that with fumigation carried on at night, where the temperature is lower and the tent leakage possibly less that a longer period may be somewhat more efficient. However, from the data given for the citricola scale, it appears that under normal conditions for commercial fumigation a 45 minute exposure is fully as efficient as a 50 or 55 minute exposure.

President G. P Weldon: Is there anyone who wishes to discuss this paper?

R. S. Woglum: I am in agreement in general with the findings as given in the paper, but in the case of eggs of the purple scale, I found that a longer fumigation period resulted in a better killing.

H. J. Quayle: It should be kept clearly in mind that these experiments were carried on with ordinary fumigation tenting material and during the daytime. Tenting material and atmospheric conditions are two variable factors in relation to the time of exposure.

President G. P. Weldon: The next paper is entitled "A Native Food Plant of *Rhagoletis fausta*," by H. H. P. Severin.

A NATIVE FOOD PLANT OF RHAGOLETIS FAUSTA O. S.[1]

By HENRY H. P. SEVERIN, PH. D., *California Agricultural Experiment Station*

Although the northern or black-bodied cherry fruit fly (*Rhagoletis fausta* O. S.) was described by Osten Sacken (12, p. 346) in 1877, the fact that this trypetid is a serious pest of cultivated cherries was not definitely determined until 1910. As to the native food plants of *Rhagoletis fausta*, Illingworth (11, p. 195) writes as follows:

"From the occurrence of the type material in the alpine regions of the White Mountains the inference would be that the native foods were wild fruits, the most natural food plants being some of the species of wild cherries or plums, or possibly the berries of some of the species of *Berberis* or *Lonicera*."

Cæsar and Spencer (5, p. 7), who have worked with this fruit fly in Ontario, state: "No injury was found on any of our native wild varieties of cherry, but only on the imported ones or on those that had grown up wild from the seeds or roots of these."

In regard to the host plants of the European fruit fly (*Rhagoletis cerasi*) Hagen (9, p. 160) writes: "Loew states that the larva lives in cherries, in *Lonicera xylosteum* and other *Loniceræ*, and in *Berberis vulgaris*, after Frauenfeld. Rosenhauer found it in *Lonicera tartarica*, and this shrub was also present in my garden for thirteen years," but as far as I know, is not infested by a trypetid.

An examination of the wild red, bird, fire or pin cherry (*Prunus pennsylvanica* L.) in Orono, Maine, near the Penobscot River, showed that most of the fruit had been punctured by insects. A few hours observation disclosed the fact that a curculio was puncturing and gnawing holes in the wild cherries to such a depth that the snout was entirely embedded in the flesh. Some of the wild cherries were opened and occasionally a Lepidopterous larva was found, but we did not succeed in breeding the moth. Most of the fruit when opened, however, showed a brown streak in the flesh extending from the skin to the stone.

On July 23, 1914, when the wild cherries were ripe, about a quart of the fruit was gathered from trees and scattered in sterilized sand within jars. During the month of August numerous yellowish puparia were sieved from the sand and were kept in moist, sterilized sand over winter. Under laboratory conditions the adults of *Rhagoletis fausta* issued during the following spring.

In the season of 1915, from July 25 to August 6, ripe wild cherries

[1] Permission has been granted by Dr. C. D. Woods, Director of the Maine Agricultural Experiment Station, for the publication of this paper.

were again gathered from trees. Puparia were sieved from the sand on August 13–27. This year, however, the puparia were kept in dry sterilized sand but not a single fruit fly emerged during the following spring. No flies issued during the second year and in all probability, the dry sand was unfavorable for the development of the trypetids.

Choke cherries (*Prunus virginiana* L.) were gathered on August 13–18, 1914, but not a single puparium of *Rhagoletis fausta* was obtained from this material.

Several quarts of cultivated cherries were purchased from owners who had a few trees in their dooryards in the residential section of Orono, and one quart was obtained from Hampden, Maine. These ripe sour cherries were placed in breeding jars on July 7–30, 1915. A few plum curculios (*Conotrachelus nenuphar* Herbst.) but no specimens of *Rhagoletis fausta* were reared. No adults of this trypetid emerged in four cages covering thirty-six square feet of soil below three cherry trees in two dooryards. It is not to be inferred, however, from what little work which we carried on, that this fruit fly does not attack cultivated cherries in Maine.

It may be of interest to compare the geographical distribution of the wild cherry (*Prunus pennsylvanica* L.) in Canada and the United States with the present known distribution of *Rhagoletis fausta*.

Sargent (15, p. 522) gives the distribution of *Prunus pennsylvanica* as follows: "Newfoundland to shores of the Hudson's Bay, and westward in British America to the eastern slopes of the coast range of British Columbia in the valley of the Fraser River, and southward through the northern states to Pennsylvania, central Michigan, northern Illinois, central Iowa, and to the high mountains of North Carolina and Tennessee, and on the eastern slopes of the Rocky Mountains of Colorado; common in all the forest regions of the extreme northern states, growing in moist rather rich soil; often occupying to the exclusion of other trees large areas cleared by fire of the original forest-covering; common and attaining its largest size on the western slopes of the Big Smoky Mountains in Tennessee." In regard to the vertical distribution, Rydberg (14, p. 193) states that *Prunus pennsylvanica* occurs at an altitude of 4,000–9,500 feet in Colorado.

According to Cæsar and Spencer (5, pp. 6–7) "British Columbia and Ontario are the only two provinces in Canada" from which *Rhagoletis fausta* has been reported. Chagnon (6, p. 14), however, in his "Preliminary List of Canadian Diptera" records *Rhagoletis fausta* from the vicinity of Montreal, Quebec.

In the United States, *Rhagoletis fausta* has been recorded from the states of New Hampshire and New York. According to Osten Sacken (12, p. 346) the male and female specimens from which the original

description was obtained were taken by G. Dimmock in the alpine region of Mount Washington, New Hampshire. Illingworth (11, pp. 191, 195) records the pest from Ithaca and Trumansburg, New York.

It is evident that the distribution of *Rhagoletis fausta* in Canada and the United States is within the range of *Prunus pennsylvanica.*

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Dr. H. T. Fernald was present and was called upon at this time by President Weldon for a few remarks. Dr. Fernald frankly suggested that he lacked an intimate acquaintance with the problems in the west, and that they were very different from those in the east. He called attention to the fact that considerable work in the west was attracting attention and being applied so far as they were applicable in the east. Dr. Fernald called attention to a Pyralid moth, *Pyrausta nubilalis*, which feeds on hemp and other similar plants, boring in the stems. It came in a shipment of rope about ten years ago and has since taken to the corn, doing as much as 30 per cent damage to the early corn, and even as high as 70 per cent damage to late corn. It has spread over an area of 100 square miles up to the present time.

G. P. Weldon: What is the chance of eradicating it?

H. T. Fernald: Since it occurs in the stems of dahlias and different kinds of grasses, the chances for eradicating it I think are rather remote.

President G. P. Weldon: The Secretary has a few more papers that were sent in by members who were not able to be present, but on account of the hour I am sorry we will have time to read such papers by title only.

The Secretary then read the title and the author's name of the following papers:

* References do not refer to *Rhagoletis fausta*.

APHIS BAKERI AND SOME ALLIED SPECIES

C. P. Gillette and L. C. Bragg

In our aphid studies we have often been puzzled in the placing of several rather closely allied forms that might be grouped around *Aphis bakeri* on account of their resemblance to this species. Probably there are other species that will fall in to this same group, but they are not known to us now.

The species treated in this paper all have short cornicles, in most cases, little, if any, longer than the hind tarsi and cylindrical in form. The cauda is rather short and broad, and in most of the species decidedly short and blunt. The antennæ are shorter than the body with the third joint heavily set with tuberculate sensoria; joint 4 also has sensoria, usually somewhat tuberculate, and joint 5 may or may not have sensoria aside from the permanent one near the distal end. The filament varies to a considerable extent in length in the different species, but never is shorter than joints 5 and 6 taken together in the alate forms.

We have been able to separate the species we have studied by the following key:

Key for Alate Viviparous Forms

Cornicles smooth, not having transverse rows of ridges or chitinous points. . *helichrysi*
Cornicles having many transverse rows of chitinous points.
- A. Hind tibiæ with numerous sensoria.
  - *a*. Sensoria on distal half of tibia (absent on fall migrants). . . . . . *viburnicola*
  - *b*. Sensoria on proximal half of tibia (also on tibia of apterous viviparous form, but not on males) . . . . *sensoriata* n. sp.
- AA. Hind tibiæ without sensoria.
  - Beak not surpassing hind coxæ . . . . *bakeri*
  - Beak surpassing hind coxæ . . . . *cratægifoliæ*

Aphis helichrysi Kalt. (Fig. 12, 1–5)

Aphis helichrysi Kalt., Monographie der Pflanzenlause, 1843, p. 102.
Aphis myosotidis Koch., Pflanzenlause, 1857, p. 57.
Aphis helichrysi Koch., Pflanzenlause, 1857, p. 135 (not this species).
Aphis marutae Oest., Aphididæ of Minn., 1887, p. 57.
Brachycaudus helichrysi, V. d. Goot., Zur Systematik der Aphiden, 1913, p. 97.
Brachycaudus helichrysi, V. d. Goot., Kenntnis der Hollandischen Blatt-Lause, 1915, p. 256.

The above list of the more important papers treating of this species, gives the synonymy as we see it. We have *Aphis helichrysi* and *A. myosotidis* from Europe as determined by Van der Goot, and a large collection of what we have been considering to be *marutæ* on a variety of host plants, and we are unable to separate them from one another, so we think they all should fall under *helichrysi* Kalt.

This species feeds chiefly upon composites, but not exclusively. Our records of food plants and dates of capture are as follows:

Place	Date	Collector	Food Plant	Form
Fort Collins	11– 4–07	L. C. Bragg	*Tanacetum balsamita*	alate, apterous
Fort Collins	6–15–09	L. C. Bragg	*Achillea* sp.	apterous
Woods Hole, Mass.	7– 3–09	L. C. Bragg	*Anthemis* sp.	
Fort Collins	10–28–10	L. C. Bragg	*Carduus* sp.	alate
Fort Collins	5–14–11	L. C. Bragg	*Senecio* sp.	apterous
Fort Collins	5–16–11	L. C. Bragg	*Urtica*	alate
Boulder	6–24–11	L. C. Bragg	*Onosmodium* sp.	alate, apterous
Fort Collins	9–30–11	L. C. Bragg	*Ambrosia artemisifolia*	alate
La Porte	9–29–11	L. C. Bragg	*Eupatorium* sp.	apterous
Palo Alto	4–26–12	H. Morrison	*Amsinckia intermedia*	alate, apterous
California	1–11–13	W. M. Davidson	*Helianthus*	alate
Fort Collins	1–27–15	L. C. Bragg	*Cineraria* sp.	apterous
Fort Collins	3–29–16	L. C. Bragg	*Bursa bursa*	alate
Fort Collins	6– 1–16	L. C. Bragg	Apple	alate
Fort Collins	12– 5–17	L. C. Bragg	*Malva* sp.	alate, apterous
				alate, apterous

Other plants on which this species has been taken in Colorado are Carrot, *Chrysanthemum*, marguerite, *Carum*, heliotrope, *Phacelia* and *Lithospermum*.

The types described by Kaltenbach were taken from *Helichrysum chrysanthemum*, "Balsamite," *Anthemis tinctoria* and *Achillea patarmica* in Europe, all composites. In northern Colorado this species often occurs in special abundance on *Ambrosia artemisifolia*, and *Erigeron canadense*, and, of the cultivated plants, *Tanacetum balsamita* and *Cineraria*.

A peculiar thing in connection with this louse, which is very noticeable where it is abundant upon the plant, is the hard excretion which seems not to be liquid, and which gives a frosted appearance to the foliage upon which it accumulates.

In addition to what is given in the above key, it might be stated that this is the smallest of the group considered, large alate individuals seldom exceeding 1.35 mm.; the antennæ is nearly as long as the body; the cornicles taper slightly in the alate form, and more noticeably in the apterous form, from the base towards the tip. We have found no evidence of either sexual forms or eggs.

APHIS VIBURNICOLA Gillette (Fig. 12, 6–12)

Aphis viburnicola Gill., Entomological News, 1909, p. 280.

This is an abundant species every spring and fall upon the snowball bushes, (*Viburnum*), and to the present, has eluded all attempts to

locate the summer food plant. It seems quite closely allied to the new species, *sensoriata*. The characters shown in figures 6 to 12 of the accompanying plate will serve to separate it readily from any other aphid known to us.

Our records on this species are very numerous. All the young of the stem mother acquire wings and leave the curled leaves for some other food plant. The sexupara begin to return early in September, the males coming a little later, when the earliest born oviparous females are about half grown.

APHIS SENSORIATA, new species (Fig. 12, 13–26)

Described from alcoholic material taken by L. C. Bragg at Log Cabin, Colorado, July 27, 1917, altitude 8,000 feet, and by C. P. Gillette, at Fort Lewis, Colorado, October 1, 1917, altitude 8,800 feet. In both cases the lice were infesting the leaves of *Amelanchier* sp. The July specimens are all apterous viviparous, and the October specimens include alate sexupara, alate males and oviparous females.

APTEROUS VIVIPAROUS FEMALE, Summer Form. The specific name is suggested by the presence of sensoria upon the hind tibiæ of adult alate and apterous virgogenia, the young apterous virgogenia and the oviparous females, and the irregularity of the occurrence of sensoria on the antennæ, especially of the apterous virgogenia, where the number varies from zero to 18 on the third segment among the 10 apparent adults we have.

General color some shade of green with transverse black or blackish markings upon the segments of the abdomen above, and a large blotch covering most of the dorsum of segments 4, 5, and 6, at least. In life, the color is black or blackish throughout, with cornicles pale greenish yellow to blackish in the older examples; antennæ, legs, cornicles and cauda black or dusky; beak attaining or even surpassing hind coxæ; cornicles short (.15 mm.), and gradually tapering from base to tip; cauda short and broadly oval at tip, not longer than width at base; length of body, 2 to 2.25 mm.; width, 1.30 to 1.50 mm.; length of antenna, 1 to 1.10 mm.; joints of antenna in the following proportions: I, 10; II, 8; III, 32; IV, 22; V, 22; VI, 10; spur, 27; joint III having from 0 to 18 oval or circular sensoria. In all but one example, the sensoria on joint III vary from 0 to 2, and on joint IV from 0 to 6. Hind tibia .80 mm. in length with numerous, small oval sensoria on the swollen basal half. Small apterous lice, down to 1.25 mm. in length, all have the hind tibiæ swollen and with sensoria, but with a smaller number than the adult. Figure 19, of Plate I shows the tibia of a nymph that does not appear to be beyond the second moult. See figures 13 to 19.

ALATE VIVIPAROUS FEMALE, Summer Form. Described from examples taken at Log Cabin, Colorado, July 26, 1917, and at Fort Lewis, October 1, 1917.

General color, black or blackish throughout; basal portions of femora and tibiæ brown; antennæ, cornicles and cauda black; cornicles slightly tapering towards the tip and as long as hind tarsi; cauda blunt and not longer than width at base; antennæ 1.20 mm. long, nearly attaining base of cornicles; joints of antennæ in the following proportions: I, 7; II, 7; III, 42; IV, 26; V, 23; VI, 11; spur,

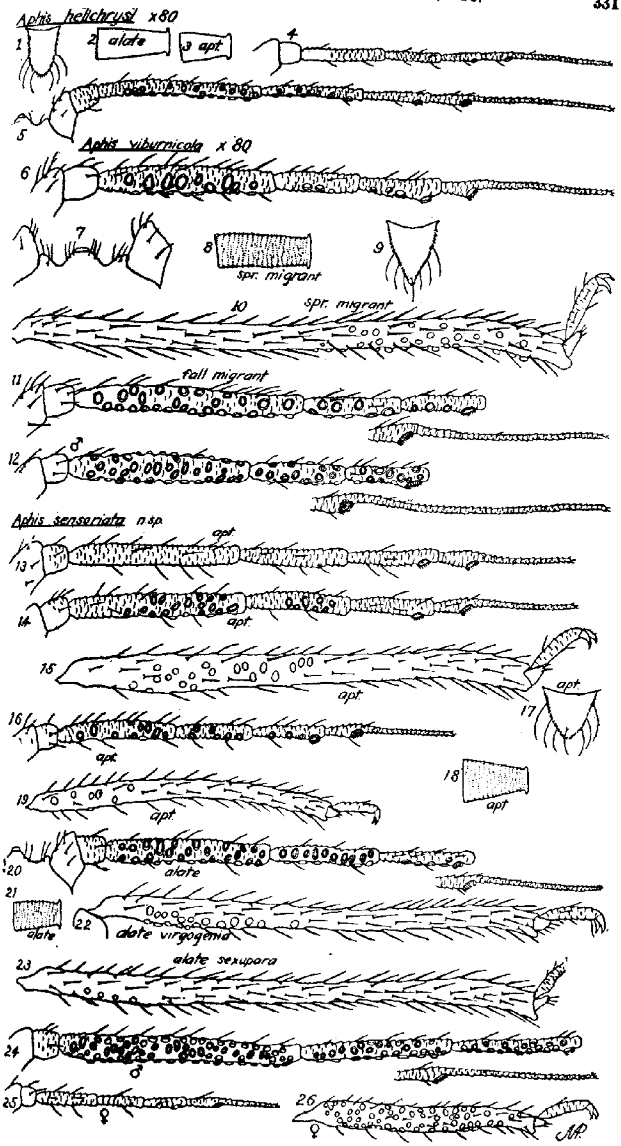
Aphis helichrysi x80
1
2 alate
3 apt.
4
5
Aphis viburnicola x 80
6
7
8
spr. migrant
9
10
spr. migrant
11
fall migrant
12
♂
Aphis senseriata n.sp.
13
apt.
14
apt.
15
apt.
16
apt.
17
apt.
18
apt.
19
apt.
20
alate
21
alate
22
alate virgogenia
23
alate sexupara
24
♂
25
♀
26
♀

Fig. 12

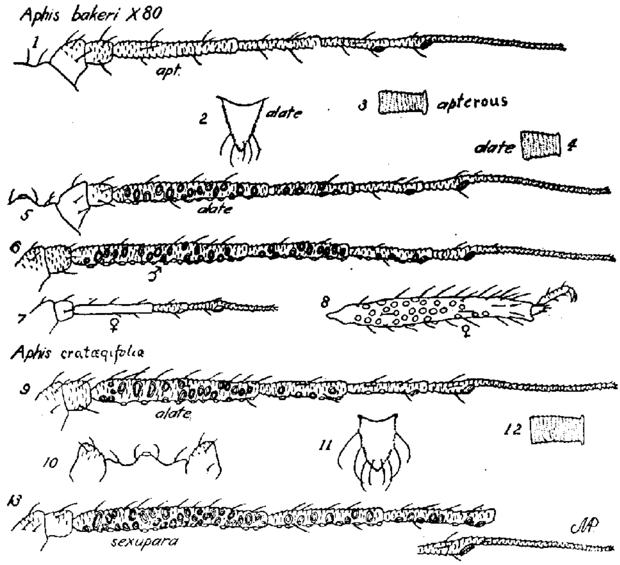

FIG. 13

31; sensoria somewhat tuberculate, joint III with about 36, joint IV with about 12, and joint V with about 6 oval or circular sensoria; length of fore wing, 2.75 mm.; venation normal; hind tibia, 9 mm. long, swollen in proximal third and with about 15 to 20 oval or circular sensoria. See figures 20–23.

ALATE SEXUPARA OR FALL MIGRANT. The fall migrants, so far as can be determined from our alcoholic material, differ from the spring migrants by having a few more sensoria on joints 3 and 4 of the antenna and much fewer sensoria on the hind tibia, about 5 to 10 in the examples studied. Examples taken October 1, 1917, on *Amelanchier* leaves at Fort Lewis, Colorado.

Fig. 12. *Aphis helichrysi.* 1, cauda; 3, cornicle; 4, antenna of apterous virgogenia; 2, cornicle; 5, antenna of alate virgogenia.

Aphis viburnicola. 6, antenna; 7, vertex; 8, cornicle; 9, cauda; 10, hind tibia of spring migrant; 11, antenna of fall migrant; 12, antenna of male.

Aphis sensoriata. 13, 14 and 16, antennæ; 15, hind tibia; 17, cauda; 18, cornicle of adult apterous virgogenia; 19, tibia of nymph; 20, antennæ; 21, cornicle; 22, hind tibia of alate virgogenia; 23, hind tibia of alate sexupara; 24, antenna of male; 25, antenna; 26, hind tibia of oviparous female.

Fig. 13. *Aphis bakeri.* 1, antenna; 3, cornicle of apterous virgogenia; 2, cauda; 4, cornicle; 5, antenna of alate virgogenia; 6, antenna of male; 7, antenna; 8, hind tibia of oviparous female.

Aphis cratægifoliæ. 9, antenna; 10, vertex; 11, cauda; 12, cornicle of alate virgogenia; 13, antenna of sexupara.

All figures enlarged 80 diameters. Original, Miriam A. Palmer, *Delineator.*

ALATE MALES. Examples taken along with the sexupara described above. Color of abdomen apparently lighter than in the alate viviparous forms; length, 1.40 mm.; antenna (figure 24) as long as the body, filament about as long as joints V and VI combined; sensoria on joint III, about 50; joint IV, about 35; joint V, about 25; and joint VI with permanent sensoria only; cornicles shorter than hind tarsi; hind tibiæ 70 mm. in length, not swollen at base and entirely without sensoria. The male is very readily separated from the other alate forms, but the spring and fall migrants resemble one another rather closely.

OVIPAROUS FEMALE. What appear to be mature apterous egg-layers in alcohol may be described as follows: color almost uniform pale yellow throughout, length 1.25; antennæ .58; and hind tibia .52 mm.; antenna with permanent sensoria only; hind tibia swollen and set with abundant sensoria throughout its entire length; cauda very broadly rounded posteriorly and broader than long. Examples taken along with the sexupara and males described above from *Amelanchier*. See figures 25 and 26.

This is an interesting species from a morphological standpoint, and it is very closely allied to *viburnicola*.

APHIS BAKERI Cowen (Fig. 13, 1–8)

Aphis bakeri Cowen, Hemiptera of Colorado, Bull. 31, Colorado Experiment Station, p. 118, 1895.
Aphis cephalicola Cowen, Hemiptera of Colorado, Bull. 31, Colorado Experiment Station, p. 118, 1895.
Aphis bakeri, Gillette, Journal of Economic Entomology, 1910, p. 405.
Aphis bakeri, Gillette and Taylor, Bull. 133, Colorado Experiment Station, p. 28, 1908.

We find this species living throughout the year on clover and giving migrants to apple and *Cratægus* in the fall. On occasional years it becomes quite injurious to red clover. This was specially true in northeastern Colorado and parts of Idaho and Utah in 1916, crops being almost ruined in some cases.

APHIS CRATAEGIFOLIAE Fitch (Fig. 13, 9–13)

Aphis cratægifoliæ Fitch, Cat. Hom. N. Y. St. Cab., p. 66, 1851.
Aphis cratægifoli Thomas, 8th Rep., Insects of Illinois, p. 101, 1879.
Aphis cratægifoliæ Oestlund, Aphididæ of Minn., p. 51, 1887.
Aphis brevis, Sanderson, 13th Annual Rep., Del. Exp. Sta., p. 157, 1902.
Aphis brevis, Patch, Jour. Agr. Res., vol. III, p. 431, 1915.
Aphis cratægifoliæ, Quaintance and Baker, Farmers' Bull. 804, p. 18, 1917.

We have not taken this species in Colorado, but have specimens from other states as follows:

Knoxville, Illinois, September 12, 1907, from Red Haw, J. J. Davis.
Orono, Maine, June 14, 1912, from *Cratægus*, Edith M. Patch.
Winthrop, Maine, October 8, 1913, from *Cratægus*, A. C. Baker.

Aphis bakeri occurs freely upon *Cratægus* in Colorado, but is distinguished by its short beak.

BIOLOGICAL NOTES ON SOME FLATHEADED WOODBORERS OF THE GENUS BUPRESTIS

By H. E. Burke, *Specialist in Forest Entomology, Branch of Forest Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture*

According to Henshaw's "List of the Coleoptera of America, North of Mexico" there are about twenty-one species of Buprestis in the United States. During the past fifteen years various members of the Branch of Forest Insect Investigations have collected and made numerous biological notes on seventeen of the species. The following paper is a brief summary of these notes.

All of the species are woodborers and so far as known are able to lay their eggs directly in the crevices of the wood as the young larvæ can thrive without any bark food. This is not always done, however, and eggs are often placed under or in crevices of the bark where the larvæ can get to the wood easily.

The observations made indicate that at least two years are passed in the larval stage and in many cases from that on up to fifteen or twenty years. Probably some larvæ from almost every group of eggs have retarded development and emerge as beetles from one to several years after the main brood.

The larval characters and biologies indicate that the genus should be divided into three groups quite similar to those determined upon by Casey in his "Studies in the American Buprestidæ" which were made from a study of the adult characters alone. The larvæ of the first group, Buprestis proper, rufipes, læviventris, confluens, etc., have a small rugose hood around the apex of the V shaped marking on the dorsal plate of the first segment and very slight rugose markings along the groove on the ventral plate. In this group pupation takes place in the spring and the beetles emerge soon afterwards. In group two, subgenus Cypriacus of Casey, aurulenta, etc., the rugose hood around the apex of the V is much larger and the rugose area along the ventral marking is broad. Pupation in this group takes place during the summer and the beetles remain in the pupal cells until the following spring. In group three, subgenus Stereosa of Casey, apricans, etc., there is no distinct rugose hood around the apex of the V but almost the entire dorsal plate is rugose as is also the ventral plate. Pupation takes place in the summer and the beetles winter over in the pupal cells as with group two.

The species of group one taken as a whole mine more in dead dry wood and seldom cause serious injury. Often they are quite bene-

ficial because they mine stumps on cutover land and thus cause rapid decay and easy clearing. The species of groups two and three often attack slightly injured trees and cause severe damage to the wood. One millman working in longleaf pine timber in the South, some of which had been boxed for turpentine, estimated his loss from the mines of Buprestis apricans as 1 per cent totally destroyed and 5 per cent reduced to the lower grades.

Such brilliantly colored species as aurulenta, adjecta, etc., may have a possible value as ornaments. Very beautiful and unique stick-pins and breast pins can be made by mounting the beetles in a gold frame.

Responsibility for the identifications of the species discussed in this paper rests with the writer. Most of the beetles have been determined at various times after consultation with Dr. E. A. Schwarz of the United States National Museum, Mr. W. S. Fisher of the Branch of Forest Insect Investigations and Dr. E. C. Van Dyke of the University of California. There is a great deal of confusion in regard to the identity of some of the species and the genus needs a careful revision by a good taxonomist who will use all of the biological data obtainable to supplement the taxonomic characters.

Buprestis rufipes Oliv.—Maryland, District of Columbia, West Virginia, Virginia and Georgia; mines dead wood of scars and limbs of live trees and wood of dead trees; hickory (Hicoria sp.), beech (Fagus atropunicea), chestnut (Castanea dentata), white oak (Quercus alba), live oak (Q. virginiana) and tulip tree (Liriodendron tulipifera); does some damage to the wood of standing dead trees and, according to Mr. T. E. Snyder, to chestnut telephone and telegraph poles; larvæ common in the District of Columbia but beetles rarely taken by collectors.

Buprestis gibbsii Lec.—Southern Oregon, sierran California; on black cottonwood (Populus trichocarpa) and black oak (Quercus californica); flies in July and August; rare; has not been reared; varies a great deal in the amount of yellow and red on the elytra.

Buprestis confluens Say.—Colorado, Utah and sierran California; mines wood of injured, dying and dead trees; aspen (Populus tremuloides) and common cottonwood (P. deltoides); flies from July to September; larvæ and work very common in the Lake Tahoe region of California but beetles rather rare; lives in the wood several years as a larva; pupates in the spring.

Buprestis lineata Fab.—Maryland, District of Columbia, Virginia, North Carolina, Georgia and Texas; mines wood of injured, dying and dead trees; loblolly pine (Pinus tæda) scrub pine (P. virginiana), and longleaf pine (P. palustris); pupates and transforms to beetle stage

from April to June; flies from April to August; causes some damage to the wood of injured and dead trees but is a benefit in clearing land because it mines the wood of stumps and causes more rapid decay. At Tryon, N. C., on July 23, 1903, Mr. W. F. Fiske found a number of very small adults of what appears to be this species on the limbs of a felled dead hickory.

Buprestis consularis Gory.—Black Hills of South Dakota, Colorado and Idaho; on dying and dead yellow pine (Pinus ponderosa scopulorum) and douglas spruce (Pseudotsuga taxifolia), especially trees attacked by Scolytids; flies in July, August and September.

Buprestis connexa Horn.—Idaho, northern and sierran California; on stumps and felled trees of western yellow pine (Pinus ponderosa) and jeffrey pine (P. jeffreyi); flies from July to September.

Buprestis nuttalli Kirby.—Colorado; one specimen of what appears to be this species collected with B. consularis on bark of dead yellow pine (Pinus ponderosa scopulorum), by Mr. Geo. Hofer on August 2, 1916, in Waldo Canyon.

Buprestis læviventris Lec.—Idaho, Arizona, Oregon and California; mines wood of injured, dying and dead trees; sugar pine (Pinus lambertiana), yellow pine (P. ponderosa), lodgepole pine (P. murrayana), digger pine (P. sabiniana) and Monterey pine (P. radiata); pupates and transforms to beetle stage from March to July; flies from May to October; causes some damage to the wood of injured and dead trees; causes rapid decay in yellow pine stumps and thus assists in the clearing of land; probably occurs throughout the range of its primary host the yellow pine and may be the same as nuttalli; one immature specimen which appears to be this species was taken from the douglas spruce (Pseudotsuga taxifolia).

Buprestis maculiventris Say.—Black Hills of South Dakota, Colorado, New Mexico and Arizona; flies from July to September in forests of yellow pine (Pinus ponderosa sçopulorum). One specimen which appears to be this species was taken by Mr. E. J. Kraus at Pike, N. H., on July 8, 1908.

Buprestis subornata Lec.—California; mines wood of dead yellow pine (Pinus ponderosa); flies from July to October; adults rather rare, found most commonly on the foliage of young trees.

· *Buprestis rusticorum* Kirby.—Montana, Colorado, Idaho, Utah, Arizona, Washington, Oregon and California; mines wood of dying and dead trees; douglas spruce (Pseudotsuga taxifolia), alpine fir (Abies lasiocarpa), lowland fir (A. grandis), and white fir (A. concolor); pupates and transforms to the beetle stage from April to July; flies from May to October; does some damage to the wood of dying and dead trees; probably occurs throughout the Rocky Mountain and

Pacific regions wherever its primary hosts, the true firs, occur; on August 11, 1915, Mr. F. B. Herbert found a male læviventris mating with a female rusticorum but in the rearing of many specimens we have always obtained læviventris from the pines and rusticorum from the true firs and douglas spruce except in the one indefinite instance mentioned under læviventris.

Buprestis langii Mann.—South Dakota, Colorado, Montana, Utah, Washington, Oregon and California; flies from June to September; numerous specimens have been taken on alder and willow leaves and some specimens on the bark of pine trees and spruce trees but none have been reared from the wood.

Buprestis striata Fab.—Thomasville, Georgia; one specimen taken on March 20, 1905, by Mr. W. F. Fiske on bark of longleaf pine (Pinus palustris).

Buprestis aurulenta Linn. (lauta Lec.).—Montana, Colorado, Idaho, Arizona, Washington, Oregon and California; mines wood of injured, dying and dead trees; western white pine (Pinus monticola), sugar pine (P. lambertiana), yellow pine (P. ponderosa) and (P. ponderosa scopulorum), jeffrey pine (P. jeffreyi), lodgepole pine (P. murrayana), digger pine (P. sabiniana), monterey pine (P. radiata), blue spruce (Picea parryana), sitka spruce (P. sitchensis) and douglas spruce (Pseudotsuga taxifolia); pupates and transforms to beetle during the summer and early fall; winters over as a beetle in the pupal cell in wood; emerges following spring and summer; flies from April to September; causes considerable damage to the wood of lightning struck, fire scorched, blazed and otherwise injured trees by mining the pitchy scars; may live for years as a larva in the wood; seems to occur throughout the range of its primary host, the douglas spruce.

Buprestis villosa Lec.—California; appears to have been named from a woolly specimen of aurulenta. Such specimens occur quite frequently among typical aurulenta.

Buprestis adjecta Lec.—Washington, Oregon, California; mines wood of yellow pine (Pinus ponderosa); flies from July to September; adults common in the Lake Tahoe region of California but the work appears to be scarce.

Buprestis apricans Hbst.—Virginia, North Carolina, South Carolina, Georgia, Florida and Texas; mines wood of injured, dying and dead trees; loblolly pine (Pinus tæda) and longleaf pine (P. palustris); pupates and transforms to the beetle in the summer and fall; winters over as a beetle in the pupal cell in the wood and emerges in the early spring; lives for several years as a larva in the wood; flies from February to May and probably all summer; causes considerable damage to the wood of blazed, fire scorched and otherwise injured trees especially

to those boxed in turpentine operations. The riddling of the trunk by the worm holes spoils the use of the wood for lumber and often shortens the turpentine crop because the weakened trunk can not support the crown during the heavy winds and is broken off. Dr. A. D. Hopkins was the first to discover and record the habits of this species which he listed as the turpentine borer in bulletin 48 of the Division of Entomology.

THE EUROPEAN EARWIG, FORFICULA AURICULARIA LINN.

By E. O. Essig, *University of California, Berkeley, Calif.*

The European earwig has been known for several years in the eastern part of the United States[1] and it may be of interest to know that it also occurs in the northwestern part, having been received in considerable numbers from Seattle, Washington, September 16, 1916. The specimens were sent by express and confined alive in a jelly glass packed in a small wooden box so that the top of the glass, which was held in place by ordinary wrapping twine and punched full of holes so that the insects would not smother in transit, was exposed. The specimens, some fifty in number and representing both sexes, arrived in Berkeley in splendid condition, not a single one being dead, and is a fine example of how insects may become accidentally established in new territory. Packed as the glass was it is remarkable that it came through without being broken and we may be thankful that the colony was not thus turned loose to repeat, in California, what it is doing in other places.

At Seattle it is reported as being abundant in houses and very destructive to roses in the garden.

In Denmark it has proved destructive to Cauliflower.[2]

Knowing that it is so close to our state we should all be on the alert to prevent its entrance and to caution collectors and the general public regarding the menace.

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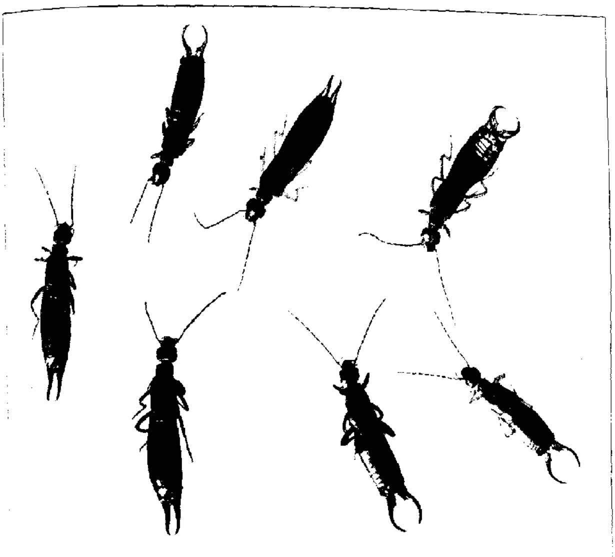
[1] Hebard, M., Ent. News, xxviii, p. 323, July, 1917—Bibliography and notes.

[2] Lind, J., Rostrup, S., and Kolpin-Ravn, F., 79 Bertning fra Statens Forsøgsvirks. i Plantekultur, Copenhagen, no. 30, 1914. (Review Appld. Ent. Ser. A. III, p. 247, 1915.)



The European earwig, *Forficula auricularia* Linn. x 3. (Original)

STORAGE OF MANURE AND FLY SUPPRESSION AT DURBAN REMOUNT DEPOT

By Charles K. Brain, M. Sc.,
Division of Entomology, Pretoria, South Africa

During a recent visit to Durban, Natal, I had the pleasure of visiting the Transport and Remount Mobilization Depôt which was established in November, 1915, in connection, chiefly, with the military operations in German East Africa. I am informed that during its existence approximately 100,000 animals, mostly horses, mules and donkeys, have passed through this depôt, and the average number maintained during most of the time has been about 3,300 with a maximum at any one time of 10,000. The chief interest, entomologically, lies in the fact that although this depôt was situated on reclaimed swamp within fifteen minutes' walk from the centre of the town, it has not caused the slightest inconvenience to the inhabitants and there has been an entire absence of smell and house-fly nuisance.

This is entirely due to the energy and common-sense methods of the O. C., Major W. F. Averre, and since some of the control measures are not identical with those generally recommended, I give the details as evolved as the work proceeded.

It may be remarked that the climatic conditions of Durban are admirably suited to the rapid multiplication of house-flies, and the question of successfully storing large deposits of stable manure in close proximity to towns and camps has always been a difficult one but one of particular importance at such a time as the present. The Remount Depôt in question is located at Lord's Grounds, the Agricultural Show Grounds of Durban, a town of some 70,000 inhabitants; as this site was not sufficiently large (25 acres), surrounding ground was taken in until an area of approximately 60 acres was involved. The show ground itself is low-lying, mainly composed of reclaimed swamp, and within half a mile of the coast. An additional 10 acres, which had been levelled and drained for use as a sports' ground, were first added and later some 25 acres of undeveloped and undrained vlei land with occasional sand-dunes completed the extent of 60 acres. Over this whole area drains and roads were constructed, the latter top-dressed with cinders, and paddocks were enclosed. The buildings already existing on the show ground were utilized for housing the staff, which numbered some seven hundred when in full force. The means employed for fly control consisted of constant attention to the collection of dung, none being allowed to remain for twenty-four hours, the systematic storage and

packing of manure, and continuous spraying with poison bait and contact insecticide.

Every day the manure and litter from stalls and paddocks was swept up and carted to huge trenches previously prepared in the sand-dunes. These trenches were dug to a depth of about ten feet, *i. e.*, down to the clay layer sublying the sand. They were often twenty feet wide and fifty to seventy long. The carting was done by a special staff of sixteen natives under a non-commissioned officer. The average amount was approximately 150 to 160 scotch-cart loads per day. This was spread out in the huge trench until a depth of about one foot was reached when other boys proceeded to cover it with a thin layer (3/4 inches) of sand, ashes or earth. It was arranged that, in carting fresh material, it was necessary to pass and re-pass over the manure already spread so that it became well pressed down and, as new layers were added, each day's deposit received its coat of sand and afterwards its rolling or ramming down. When a trench was filled it was covered with a layer of a foot or so of earth or sand and then thoroughly rolled for two or three days. Disinfectants or lime were not added. This method of storing produces a dense peaty mass of manure which analysis shows to be of particularly good quality. One large deposit of the manure was purchased recently by an Association and a small trolley-line laid down for its removal to the railway siding.

For sweeping manure from the stalls, hard brushes are used; and, although the work is thoroughly done, there is always a number of flies around. To deal with these four natives under a "conductor" are constantly treating them with a contact spray. The mixture used consists of:

Caustic soda	2 pounds	
Boiling water	50 gallons	
Paraffin	5 gallons	added while hot
Hycol	5 gallons	

An attempt is made with this to actually hit the settled flies and it was found that a broad-bore garden syringe was more effective than an ordinary spray pump.

Fly bait consisting of:

Arsenite of soda	5 pounds[1]
Black sugar	5 to 20 pounds
Boiled in water	25 gallons

is distributed on blue-gum branches and pieces of sacking. These are

[1] This seems excessively high in arsenite, being twice the amount usually recommended. It has been reported by some workers that if too much arsenite be used it acts as a repellent, defeating the purpose of a bait. C. K. B.

placed in all latrines, dormitories, cook-houses and stores and are constantly renewed.

That the measures adopted have proved effective is well illustrated by the fact that on several occasions the Oval of the show grounds has been used for patriotic functions attracting thousands of the public, and yet on no occasion has the least inconvenience been caused by the close proximity of the large number of animals in the Depôt, nor by the thousands of tons of stored manure.

Scientific Notes

A Promising New Contact Insecticide. From the results of a series of experiments, it has been determined that the most efficient contact insecticides must be of an oily or soapy nature. Based upon these observations, a new contact insecticide has been made by the formation of a soap or soap-like salt by the union of nicotine and oleic acid. This chemical is nicotine oleate. It dissolves in soft water forming a soapy solution which may be used to emulsify an animal, vegetable or mineral oil.

The following experiments give an idea of its value. First, Nicofume, containing 40 per cent of nicotine diluted with water to give a nicotine content of 1 part in 1,000 of water, killed 95 per cent of the chrysanthemum aphis. Nicotine oleate, diluted to give 1 part of nicotine in 1,500 parts of water, killed 96 per cent, while diluted to 1 part of nicotine in 4,500 parts of water killed 63 per cent.

Second, Nicofume, diluted to a nicotine content of 1 part in 1,500 with 2 parts of laundry soap added, killed 93 per cent of the chrysanthemum aphis, while the nicotine oleate with a nicotine content of 1 to 2,250 killed 97 per cent.

Third, Nicofume in aqueous solution does not kill mealy-bugs. Nicotine oleate used at the rate of 1 to 500 will kill a few mealy-bugs and a few egg clusters. Two per cent of a vegetable, animal or mineral oil emulsified in the nicotine oleate solution will kill mealy-bugs and their eggs. An emulsion containing 1 part of nicotine in 500 parts of water with 2 per cent kerosene killed 79 per cent of the adult mealy-bugs and their older larvæ, 98 per cent of the eggs, and 98 per cent of the young larvæ.

Fourth, Preliminary experiments have shown that about 85 to 90 per cent of the soft scale on greenhouse plants may be killed using nicotine oleate at a dilution of 1 part of nicotine to 500 parts of water.

Fifth, Preliminary experiments have shown that adults and larvæ of the white fly may be killed at the same dilution as used for the soft scale.

All experiments mentioned were conducted under laboratory conditions, care being taken to hit all the insects used in the experiments. Under field conditions it may be necessary to use a higher percentage. Nicotine oleate being nonvolatile it is more necessary to insure striking all insects than in the use of a volatile compound like nicofume.

Nicotine oleate may be made directly from any nicotine preparation containing free nicotine. Two and one-half parts of a 40 per cent nicotine solution unites with 1¾ parts of commercial oleic acid or red oil. Four and one-fourth parts of this soap will then contain 1 part of nicotine or will equal 2½ parts of the 40 per cent nicotine solution. Two and one-half quarts of 40 per cent nicotine solution costing about $7.00 can be mixed with 1¾ quarts of commercial oleic acid costing about 90c. making 1¼ gallons of nicotine oleate. For spraying to control plant lice, where a gallon of a

40 per cent nicotine solution costing about $11.00 would be used to make 500 gallons of spray, 1 gallon of nicotine oleate costing about $6.50 would make 650 gallons of a spray solution as effective if not more effective than the spray containing free nicotine. The nicotine oleate will cost the farmer about $1.00 a hundred gallons where the free nicotine spray will cost $2.20 per hundred gallons.

To make the oil emulsion spray with nicotine oleate 10 parts of kerosene is mixed with 1¼ parts of commercial oleic acid and then 2½ parts of 40 per cent nicotine solution is added and thoroughly shaken. Ten parts of water is then added and again thoroughly shaken. For use against mealy-bugs, white fly and soft scale this quantity is then mixed with 480 parts of soft water.

In sprays where nicotine oleate is used the spray water must be soft (rain or distilled water). To make nicotine oleate only those tobacco extracts containing free nicotine can be used. The stearate or palmitate of nicotine may be made in the same way, but is not as effective a spray as the oleate. Nicotine oleate is not volatile, hence should not be used on plants to be eaten, such as lettuce. The effect on plants has not been completely studied although sprays containing nicotine oleate equal to 1 part of nicotine in 100 of water did not injure tomatoes or coleus. Slight injury was noted on tender leaves of greenhouse roses when sprayed at the above strength.

On dormant trees the use of a rather nonvolatile oil such as linseed, cottonseed, or fish oil emulsified with nicotine oleate should be valuable for the destruction of insect eggs or scale insects.

A PATENT HAS BEEN APPLIED FOR THIS COMPOUND AND WHEN OBTAINED WILL BE GIVEN TO THE PUBLIC SO THAT ANYONE WILL BE ABLE TO MANUFACTURE IT.

William Moore

Notes From El Centro (California) Field Station. Not a trace of *Hippodamia convergens* has been seen in or around Imperial Valley since the advent of midwinter conditions, although the winter has been a very mild one thus far. Search in plant lice infested grain fields, basal volunteer shoots of cotton, along the banks of the Alamo and New Rivers, and at altitudes from 1,000 feet to 4,000 feet in the Laguna Mountains, west of the Valley, has failed to reveal any indications of hibernating ladybirds.

An inspection of grain fields in scattered parts of the Imperial Valley, made January 31, showed that all fields over a week old were quite generally infested with *Aphis avenæ*. The average infestation, as based on counts of 160 stools, was computed at that time to be 69.4 per cent. The colonies, which consisted of wingless females, their young, occasional nymphs, and rarely a winged migrant, appeared of rather recent establishment. Although parasites and syrphid larvæ were seen, no *Hippodamia* individuals were present.

The cotton aphis (*Aphis gossypii*) is quite commonly seen on *Malva* leaves, to which related plants they have probably migrated upon the recent frosting of the cotton foliage.

E. A. McGregor

JOURNAL OF ECONOMIC ENTOMOLOGY

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The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photo-engraving may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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The appearance of number 11 of the Emergency Entomological Service, United States Department of Agriculture, reporting coöperation between Federal, State and Station Entomologists and other agencies, marks the beginning of a second season under war conditions. A timely summary such as this is invaluable to every economic entomologist, covering, as it does, all fields of activity and giving early and reliable information regarding developments in adjacent states, as well as in more remote parts of the country, and it is to be hoped that this service may become a permanent feature. Information is of value largely in proportion to its timeliness and all too many reports and bulletins appear long after the insects they discuss have ceased, for the time being, pernicious activity. This emergency service—it should be designated seasonable service—remedies this difficulty in large measure and it may well be supplemented and extended by a somewhat modified local service in the various states, coöperating particularly with county agricultural agents and others in position to disseminate information and secure the effective adoption of preventive or control measures. The Liberty Loan and Red Cross have set high standards in coöperation. It is all for the same cause. Can entomologists secure, in their own lines, relatively as good results?

Current Notes

Conducted by the Associate Editor

Mr. Albert Hartzell has been appointed assistant in entomology at the Iowa College and Station.

Prof. E. H. Dusham has been promoted to be Professor of Entomology at the Pennsylvania State College.

S. W. Frost, Cornell University, has been appointed entomologist of the Adams County, Penn., laboratory to study fruit insects.

Prof. John H. Comstock of Cornell University was recently elected a correspondent of the Academy of Natural Sciences of Philadelphia.

Mr. R. R. Reppert, graduate assistant of the Kansas State Agricultural College, has accepted a position as Assistant Entomologist of Virginia.

Dr. E. F. Phillips, Bureau of Entomology, attended the meeting of the National Beekeepers' Association at Burlington, Iowa, February 19–20.

Prof. Herbert Osborn of the Ohio State University, has been appointed an associate on the staff of the Ohio Agricultural Experiment Station.

Mr. T. H. Parks, extension entomologist of the Kansas State Agricultural College, resigned April 15 to accept a similar position with Ohio State University.

Mr. W. E. Jackson became assistant entomologist of the Texas Station, October 1, 1917, and has taken up work in combating foul brood diseases of the apiary.

Dr. J. H. Merrill, assistant professor of Entomology, Kansas State Agricultural College, has been appointed State Apiarist of Kansas. He still retains his position with the College.

Mr. M. D. Leonard of Cornell University has been appointed entomologist at Girard, Erie County, laboratory of the Pennsylvania State College, and will study vegetable insects.

The Agricultural Appropriation bill now in conference carries an item of $500,000.00 for the pink bollworm work in Texas and Mexico, including the border inspection service.

Mr. P. W. Mason, assistant professor of Entomology at Purdue University, Lafayette, Ind., has resigned to accept a position in the Bureau of Entomology of the U. S. Department of Agriculture.

Messrs. R. W. Gies and J. B. Leslie, Chief Inspectors respectively of the Union and Bergen County, New Jersey, Mosquito Extermination Commissions, have received commissions in the Sanitary Corps of the national army.

Mr. E. O. G. Kelly, for many years in charge of the Wellington (Kansas) Station of the Federal Bureau of Entomology, has accepted a position as Extension Entomologist with the Kansas State Agricultural College.

According to *Science*, Prof. James Zetek, professor of biology and hygiene at the Instituto Nacional de Panama, has been appointed entomologist of the Board of Health Laboratory of the Ancon Hospital, Canal Zone.

Mr. George S. Demuth, Bureau of Entomology, left Washington February 20 for a six weeks' trip in California where a series of meetings on the control of bee diseases were held in coöperation with E. F. Atwater of the Bureau.

According to *Nature* the Entomological Society of Spain has recently been founded, with its center for the present at St. Saviour's College, Saragossa. Dr. Hermenegildo Gorria of Barcelona is president and the Rev. R. P. Longinos, Navas, S. J., Secretary for 1918.

Mr. C. H. Hadley, extension entomologist, Pennsylvania State College, has been placed in charge of entomological research, and for the present is to be located at Bustleton, Philadelphia County laboratories, as entomologist and will give attention to truck crop insects.

Prof. C. W. Woodworth of the University of California is spending his sabbatical year in Nanking, China, in helping to develop the Agricultural College of the University of Nanking, along entomological lines. Entomological literature is needed by the University Library.

A hearing was called at 10 o'clock a. m. for May 28, by the Federal Horticultural Board at Washington, D. C., to receive testimony regarding the advisability of restricting or prohibiting the importation of nursery plants into the United States from foreign countries.

Prof. William A. Riley goes to Minnesota as Professor of Entomology and head of the Division of Entomology and Economic Zoölogy and not, as has been stated earlier, as Professor of Parasitology. He plans to continue teaching along lines he developed at Cornell University.

The following resignations in the Bureau of Entomology are announced: P. W. Erbaugh, bee culture, to enlist in the Marine Corps; David Running, extension work in bee culture, New York; J. H. Wagner, bee culture; H. B. Parks, cereal and forage insects, to enter the Texas state extension service; E. Phillip Barrios, to take up county agent work in Louisiana; Roswell C. Pickett, extension work, truck crop insects, Texas.

W. Dwight Pierce, with the approval of Dr. L. O. Howard, is conducting a class in the entomology of disease, hygiene and sanitation, with special reference to army needs and the possibility of there being a call for a large number of men prepared for service along these lines. There is a weekly lecture in Dr. Hunter's room and this is supplemented by reports upon special topics from various members of the class. The proceedings are mimeographed and distributed to the class and others interested even if they are not able to attend the lectures. Over one hundred copies of the proceedings are now distributed.

Mr. P. van der Goot, of Buitenzorg, Java, Entomological assistant at the great sugar experiment station there, was in Washington from the 15th to the 25th of February, looking up matters connected with the injurious insects of tropical crops. Mr. van der Goot is especially well known by his writings, his large contribution to the knowledge of Aphididæ of Java and other papers of importance. He speaks English very fluently, and is still a young man with many years of work ahead of him. He is on his return to Java from Holland, and in crossing this country will stop at New Orleans, Tucson and Pasadena, and hopes to spend ten days in Hawaii.

The following transfers have been made in the Bureau of Entomology: R. H. Hutchinson, assigned to work on human lice, New Orleans, La.; A. C. Johnson to Dallas, Tex., for three months; F. S. Chamberlain, to take charge of tobacco bud worm work, Quincy, Fla.; F. R. Cole, truck crop insects, to cereal and forage insects, Forest Grove, Ore.; Robert Larrimore, special field agent, extension service, to research service, truck crop insects; F. B. Milliken, stored insect investigations to extension service, lower Mississippi Valley; D. C. Parman, Uvalde, Tex., research work on animal insects, to extension service in the same subject; Charles F. Stiles, from cereal and forage insect extension work to apicultural extension, Oklahoma; W. W. Yothers, entomological assistant, tropical fruit insects, to extension work (temporarily) in the same subject.

According to *Science*, "Mr. W. Hague Harrington, one of the best known of the older Canadian entomologists, died on March 13 at Ottawa, Canada, at the age of sixty-six years. Mr. Harrington was born in Nova Scotia, and entered the federal civil service at Ottawa in November, 1870, eventually reaching the rank of superintendent of the Savings Bank Branch. He was one of the founders of the Ottawa Field Naturalists' Club, and at one time was president of the Entomological Society of Ontario. In 1894, he was elected a fellow of the Royal Society of Canada. For many years his main interest in life was entomology, and he brought together a large collection of Canadian Coleoptera and Hymenoptera. He was a systematist of recognized standing, and was probably the highest authority on Hymenoptera in the Dominion of Canada. He was a striking example of that class of men who have done pioneer work in natural history in Canada and the United States, while pursuing this work as a hobby rather than as a vocation."

Appointments have been made in the Bureau of Entomology as follows: R. B. Wilson, Cornell University, bee culture in Mississippi; George H. Rae, bee culture, New York; G. H. Gale, Maryland Agricultural College; Dr. Frank Thomas, special field agent, extension work with deciduous fruit insects, Auburn, Ala.; R. L. Clute, Michigan Agricultural College, stored product insects, Gainesville, Fla.; S. E. McClendon, stored product insects, Athens, Ga.; Felix Dabadie, truck crop insects, Louisiana; Miss M. A. Connell, California, truck crop insects, Washington; W. O. Hollister, Kent, Ohio, a graduate of Connecticut Agricultural College, cereal and forage insects, West Lafayette, Ind.; B. L. Boyden, recently resigned, reappointed for extension work with truck crop insects, Oxnard, Cal.; Forrest N. Anderson, Coffeyville, Kan., truck crop insects, extension work in Texas; Clayton J. Foster, deciduous fruit insects, extension work, Houston, Tex.; Leroy A. Shaw, cereal and forage insect extension work, Montana; Roscoe Wells, extension work, insects affecting domestic animals.

Mailed June 22, 1918